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Jonas Bjarnason

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A Manual of Fish Processing I. Curing of Salted Fish

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Canada

A MANUAL OF FISH PROCESSING

I.

Curing of Salted Fish

by

Jónas Bjarnason

Published by the Fishing Industry Research Institute
Reykjavík, Iceland

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Sources and contributors to the writing and data collection

The managing editor of this manual, Jonas Bjarnason of the Fishing Industry Research Institute, has been assisted by:

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Geir Arnesen, chief engineer (Salt and its importance),
Sigurjon Arason, departmental engineer (Premises and equipment for the curing of salted fish; Drying of salted fish).

Various employees from the branch offices of the Fishing Industry Research Institute have participated in the collection of information on defects in Icelandic salted fish.

Significant contributions have been made by employees of S.I.F. Special mention must be made of:

Sigfus Magnusson, inspector,
Loftur Loftsson, engineer.

Sigfus provided much information on the grading of salted fish whilst Loftur contributed to numerous points concerning salting. In addition, directors Fridrik Palsson and Valgard Olafsson have given liberal assistance, as has Sigurdur Haraldsson, office manager, and Einar Johannsson, inspector. Gudjon Petursson, who is a fish appraiser and on the staff of the Fish Processing School, has provided various information on the grading of salted fish. Sigurdur Oskarsson, teacher at the Fish Processing School, gave direction on the subjects of processing and splitting.

A large number of working appraisers, managers and fisheries workers have also willingly provided information.

Use has been made of a number of reference texts. In particular we have utilized the various technical information reports issued by the Fishing Industry Research Institute, covering i.a. the curing of salted fish, most of which have been authored by Geir Arnesen. We have also based ourselves on the "Processer og produkter i norsk fiskeindustri, tørking, salting, røyking" by Torbjørn Pedersen (Universitetsforlaget, Oslo, 1981). Certain data has also been obtained from the Bulletins of the Icelandic Engineering Society 1-6, 1967, by various authors.

We have also found some support in the "Instructions and directives on the grading and production of uncured salted fish, dried salted fish, salted flitches of black pollack (coalfish), salted flaps" issued by the State Fish Appraisal Authority in 1971, and in the "Curing of Salted Fish" (1981) and "Salted Fish Grading" (1982), issued by the Fish Products Inspectorate.

1. Introduction

The salting of fish is an age-old conservation method, besides drying and pickling the most common method of food preservation in Iceland in the past. Preservation is based on lowering the "water pressure" or reducing the "usable" water for bacteria, toxins and mould spores, e.g. microorganisms. Generally speaking, microorganisms do not thrive without water. When water is saturated with salt its usefulness is reduced so that only a few species of microorganisms can thrive; however, this changes with increasing temperature. Salting of fish actually amounts to drying, which also aims to counteract bacteria, especially when we speak of dried fish or so-called fully cured salted fish which contains much less water than fresh cured or un-cured salted fish. Presently more than 90% of the salted fish output is in the form of fresh fish, but in earlier times all salted fish was dried.

When fish is salted and dried, changes occur which persist in spite of soaking, i.e. immersion for the purpose of salt removal. To some extent the muscle tissue has undergone the type of changes referred to as "denaturation" which also makes it rigid. However, these changes must be controlled so that the fish does not crumble in the mouth after cooking, yet being tough to chew. In addition, there are also taste changes. Some of the early changes are presumably caused by various bacterial activity, but later taste changes due to chemical processes and denaturation take place without the influence of bacteria. All these changes are components of the curing process; a word which represents those positive changes which the curing of salted fish aims to produce.

The average buyer of salted fish has developed both a taste for it and a complex method of preparation based on the characteristics of the product. In spite of new techniques and more recent (aseptic) preservation methods aimed to protect the delicate foodstuff which fish constitutes, salted fish remains a favourite food in those countries which do not scoff at salting in the absence of other methods of preservation. This is due to consumption habits and on the fact that salted fish quite simply is a profitable commodity due to the demand and buying power of customers willing to pay a comparable price for salted fish relative to fish cured or preserved by other methods. In the present-day community of industrialized nations with significant purchasing power there is, besides, a strong tendency to maintain a broad variety of foods for consumption. Innovations therefore tend to result in a proliferation of products, and not necessarily in the rejection of older types of food, although consumption may drop.

Salted fish is very popular in certain parts of Spain, and in Portugal in general. A multitude of recipes exist and it is astonishing how tasty some of these dishes are even at a first try. Icelandic culinary habits are very simple and Icelanders therefore find it hard to understand the degree of popularity good salted fish enjoys in many places, especially in the Roman Catholic countries. "Bachalao a la vizcaina" and "bachalao al pilpil" are examples of gentlefolk's food in Spain which only those can criticize who have tried it. In Portugal, "bachalhau a braz" and "bachalhau a gomes de sa" are banquet dishes.

The attitudes to consumption and buying of salted fish are obviously different in terms of individual product shortcomings, depending on the market country. Certain markets must sometimes be given special consideration both in the production and the quality grading. Some markets naturally request a certain size, species or degree of drying for various reasons, but that is a different matter. The curing procedure described in this manual attempts to focus on the product most likely to be regarded most favourably by the "average consumer" who, of course, is a mythical individual. The collection of all available information on consumer reactions over the years has led to existing opinions and production methods, assisted by what written information there is. The desires of countless consumers who state that they generally are not in the habit of choosing salted fish for their meals in favour of other foodstuffs, will never be fully known. We can only approach the consumers' viewpoints by various indirect routes.

The curing of salted fish is a traditional industry in Iceland, associated to some degree both to a lifestyle and an attitude to living.

2. PRODUCT DESCRIPTIONS AND DEFINITIONS

2.1. Main commercial products

TABLE 1.

Fish species	Product	Size, packaging	# of quality grades	Output 1981 (1000 tons)
Cod	split. soft-cured	10/20 fish per package	4(5)	
		20/30	4(5)	41.236
Cod	split. soft-cured	30/40	4(5)	8.899
Cod	split soft-cured	40/60	4(5)	5.764
Cod	split. soft-cured	60/100	4(5)	1.397
Cod	split. dried fish (Cura Corrente, 7/8 dry)	10 sizes	4	573
Cod	split. dried fish (very dry, extra dry)	10 sizes	4	81
Cod	fillets. soft-cured	4 sizes	2	560
Cod	wings. soft-cured	3(2) sizes	1	42
Cod	small fish soft-cured	1 size	1	6
Ling	split. soft-cured	1(2) sizes	4	744
Ling	split. soft-cured	4 sizes	2	3
Ling	split. dried fish	8 sizes	4	45
Cusk (Tush)	split. soft-cured	1 size	1	9
Pollock (Coal-fish)	split. soft-cured	3 sizes	4	2.749
Pollock	fillets. soft-cured	9 sizes	2	948
Pollock	split. dried fish	5 sizes	4	329
Haddock	split. soft-cured	1 size	3	29
Blue ling	split. soft-cured	1 size	1	16
Blue ling	split. dried fish	8 sizes	1	18
Waste	dried	1 size	1	175

2.2.1 Fully-processed salted fish, definition

Regulation No. 71 of 1973 on the Appraisal of Salted Fish for Export states in Section 6: "Fish that is not fully-processed is non-gradable." - The 1982 guidelines of the Seafoods Production Control on salt-fish appraisal also mention factors that appraisers should examine before they appraise salted fish:

a) Examine whether the fish is adequately processed to be gradable.

b) Examine whether there is a risk that redness or other comparable defects are present in the fish.

3) Examine whether the fish is sufficiently clean and well-cured.

4) Examine whether the fish is properly salted.

The above factors are the only explicit requirements on characteristics that the fish must satisfy to be considered exportable soft-cured salted fish. They are matters of opinion that are not expressly defined in writing.

2.2. Soft-cured salted fish

Soft-cured salted fish generally means split fish (or fillets) of cod, ling, cusk (tush), pollock (coal-fish), haddock or blue ling, which have been salted and cured in the usual manner in brine and stacks or in stacks with plenty of salt until they are "fully-cured" as defined in 2.2.1. Soft-curing aims at a "state of equilibrium" in weight and moisture content without air drying. The moisture content is then generally within the range of 50-57%. The moisture content may vary depending on the characteristics of the raw material as well as the curing methods, and the moisture content alone is not the definitive criterion on whether the fish would be called "fully-processed" soft-cured salted fish or not, unless the moisture content is too high (higher than 55%).

What has here been discussed as "soft-cured" salted fish is simply a product that has been developed in Iceland during the last few decades, and it is actually based on "heavy salting", until weight loss and salt uptake largely stop at the temperature that is most common in Icelandic salt-fish processing plants (5-10°) and at high air humidity. There are naturally almost countless types of soft-cured salted fish with varying moisture and salt contents, and the type that is discussed here is the "natural" product based on the prerequisites discussed.

About the properties of soft-cured salted fish:
The moisture and salt content of soft-cured salted fish has at least three-fold relevance ... :

a) It indicates the degree of curing ("cured", "mature") as defined by taste and other characteristics. When the water content has reached 52-54% or lower and the salt content is normal, the fish is probably "fully processed" on the basis of "normal" or "usual" salting conditions.

b) It indicates "firmness" or "rigidity" of the flesh as well as the likelihood that the fish will stand up to normal transportation without breaking up or softening, which would cause it to drop in quality between packing and arrival at destination.

c) It indicates the probability of weight decrease during transportation and determines the dry content which naturally is the factor of most interest to commercial stakeholders, especially if the drying process is ongoing.

The drier the fish at packing, the lighter it will generally be on transportation to destination. In 1983, S.Í.F. conducted extensive experiments relating to the exportation of fully processed "lightly salted" fish; these are discussed under 2.2.2.

The following is an attempt to provide definitions for the above properties:

"Fully processed" soft-cured salted fish, definition:
1st quality "fully processed" soft-cured salted fish has the following properties:

a) The definition refers to product conforming to the requirements set out below and which is graded as 1st quality under the quality definitions in 5.1.1. or the official appraisal definitions in 5.1.2, and constitutes product optimally free of defects and faults.
b) The product absorbs water at the "normal" rate during soaking and maintains its texture and form during 36 hours in cold water (10-15^{o}C or colder).
c) After soaking and "usual, traditional preparation" the fish possesses its characteristic salted fish taste and smell, soft consistency and mucosity. After cooking it may contain coarser strands than is usual in fresh fish,

but must not be tough to chew. The salty taste will vary depending on how thoroughly the fish is soaked, but the special characteristics of salted fish must always be present.

d) Soft-cured salted fish is deemed fully processed when it has acquired those properties which make it stand up to regular transportation to the country of destination in "customary canvas packaging" without losing more than 5% in weight on average. It must also withstand the usual degree of rough handling in transit without breaking up, thus arriving in poorer condition than when packaged.

Characteristics:

Appearance:

The fish is adequately processed for export when its hue or basic colour has become predominantly white and is neither translucent nor "watery". Its consistency changes should resemble those occurring in a boiled egg. Fully cooked albumen is white and not transparent, while in its half-cooked stage it will resemble water into which milk has been poured. Denaturation is the cause of changes in the albumen of salted fish upon cooking. When the fish is gripped by the neck and held straight out (horizontally), it must sag but not hang down limply.

When a finger is thrust firmly into the neck portion of fully processed fish, there must be no water accumulation around the depression site.

Measurements:

The fish will contain an average of 53% moisture and must have no significant breaks or cracks. Fish in the 3rd and 4th quality grades have a moisture content of 51% or less. The salt content will be around 18-20%. Other quality grades conform to the specifications shown in 5.1.1. and 5.1.2. and fall short of the properties listed under b, c and d above.

2.2.2. Salted cod products, description

Cod: As shown in Table 1, split and soft-cured cod is by far the most common Icelandic salted fish product. Gutted and bled cod are headed and split by machine or hand as described in 4.5.2. and 4.5.3. in such a way that the backbone is cut away from the neck (the flesh on the back of the head) and halfway down. When fish split in this manner is laid skin-side down on a table before a spectator with the fishtail facing him, he will notice that the backbone at the tail will be on the right side, and not in the thinner part of the tail which turns to the left. This is worth noting, since it is contrary to the custom e.g. in Norway and Canada. When the fish is ready for packaging, it is classified by weight. To estimate the size of the different weight classes you can measure the length of the fish as shown in figure 1 and thereby determine its weight. By dividing the weight by 50 you will obtain the estimated number of fish per package.

Cod is classified in five (six) weight categories. Each category is subdivided in 4 (5) quality grades, except for small fish which are packaged together (Nos. 1 and 2). The fish is exported in four types of packages. The size of canvas packages is 50 kg net, but in recent times product is also packaged in 25 kg waxed cardboard boxes and arranged on trays. There are fixed rules for the marking of packages, based on the official regulations discussed in 2.4.

There has been some production of salted cod flitches*) in recent years (560 tons in 1981). These flitches correspond to frozen "B" flitches with flaps and upper ribs. The flap ends are removed by oblique cuts. One may also cut away damaged flaps along with the upper ribs, or up against them, as shown in the illustration. Flitches are classified in four weight categories (700 g and over, 400-700 g, 200-400 g and 100-200 g). We shall only deal with two quality grades, A and B, with A being 1st quality and B 2nd quality.

There is little to say about salted flaps. They may not be smaller than 130 cm^2. Flaps are packaged in one size category and one quality grade which compares with 1st quality.

Special directions for processing and curing of special products can be obtained from S.I.F.

Coal-fish, ling and tush: These fish are split and flitched in the same manner as cod (see illustration).

The quality of coal-fish flitches can often be improved by trimming away bruises and other defects. However, it is not permitted to package shorter flitches than

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*) Please note that translator uses the word "flitch" for fillet and filleting

30 cm, i.e. trimming must not reduce the flitch to less than this minimum size.

The instructions and guidelines published in 1971 by the State Fish Appraisal Authority are generally applicable to the grading of salted coal-fish flitches. The same requirements apply as for quality grading of soft-cured cod, except that the darker texture of coal-fish is not regarded as a specific defect. It is permitted to co-package 1st and 2nd quality product which is then marked AB. 3rd grade product must be packaged separately. Certain conditions apply to the co-packaging of AB product.

Classification is by weight. There are eight weight categories, each based on a fixed minimum weight and a defined number of flitches per 50 kg package.

2.2.3. Fully cured "lightly salted" fish

Innovations in packaging and changing transportation technology have opened the way for new production processes.

Packaging in water-tight cardboard boxes which counteract deterioration and prevent mishandling are gaining importance. Tests have revealed that fully cured, but "lightly salted" fish has become a popular product. Experimental salting of a few hundred tons in 1983 provided a positive experience and the experiment is continuing. The main object of this curing process is to fully salt the fish by a rapid process, but not to expose it to a great deal of pressure.

Examples of curing procedures:
3 days in brine followed by 7-10 days in the fish-house;
5 days in brine followed by 5-10 days in the fish-house.

At this stage of curing, the fish is not free from glassiness of texture and is therefore difficult to grade.

2.2.4. Fully cured "medium processed" salted fish

The use of containers has made it possible to send fish out of the country at an earlier processing stage than previously.

A large number of producers in 1983 pre-graded their salted fish early in the curing process and packaged better grade product (I and II) in boxes or on trays with a large quantity of salt to diminish pressing. Market acceptance of this fish has been excellent in areas where the fish is sold soft-cured.

Poorer quality fish on the other hand was pressed in the customary manner until the product gained the characteristics of fully processed fish. All signs indicate the this division of product for processing will continue.

2.3. Packaging

Salted fish and other salted products are now exported in four types of packages, namely:

a) Trays, 100 x 120 cm containing 1000 kg
b) Waxed cardboard cartons, various sizes (mainly 60x80x15 cm and 60x40x14 cm), 25 or 50 kg
c) Canvas packaging, 50 kg parcels
d) Wooden boxes

Most soft-cured salted fish is now packaged on trays. All fresh fish sold to Portugal is packaged on trays, as is some of the salted fish destined for Spain and Italy. The use of cardboard cartons for soft-cured fish is increasing. The Greek market now accepts all types of fish products in this type of packaging, as does the Italian market to an increasing extent. All cod flitches and most stockfish is exported in cardboard cartons, as are coal-fish flitches to Germany.

Canvas packaging is an old custom which actually suits stockfish better than fresh fish. However, traders were long reluctant to accept salted fish transported in any other way than in canvas packages; but this has changed in recent times.

Cardboard cartons are a more expensive form of packaging than trays or canvas packages due to the cost of materials. However, cardboard cartons keep the fish softer and better in appearance, besides which there is reduced weight loss. It has been stated that the increased packaging costs are offset by better utilization and preservation of quality, as well as a reduced risk of weight shortfall.

Packaging in cardboard cartons is a very clean procedure which protects the goods from dirt and moisture during storage and transportation. This procedure also has an indirect sanitary effect by increasing the awareness of hygiene among workers during the curing of salted fish in general.

Most salted fish is now stacked loosely on trays, 100 x 120 cm, for international transportation. It is also possible to stack cardboard cartons on trays for sea transportation through to destination, without the goods suffering on the trays. Experiments have also been made with the transportation of salted fish which has been salted or loosely re-stacked on the trays. Experience is still limited.

Innovative packaging methods may well arise in the future, examples being various plastic or airtight containers. Developments in this area require large-scale efforts and are usually undertaken in the customer countries themselves, being largely beyond the capabilities of Iceland. For this reason it is important to monitor developments in this area.

2.4. Marking of packages

Special regulations apply to the marking of all salted fish products. Guidelines are published by the Sales Association of Icelandic Fish Producers and the Fishing Industry Research Institute. The regulations (72/1972) i.a. direct that all salted fish products being exported from Iceland must be marked i.a. with regard to the following:

1. That the product is manufactured in Iceland
2. Species of fish
3. Date of grading and packaging
4. Definition of quality grade
5. Exporter's identification
6. Manufacturer's identification

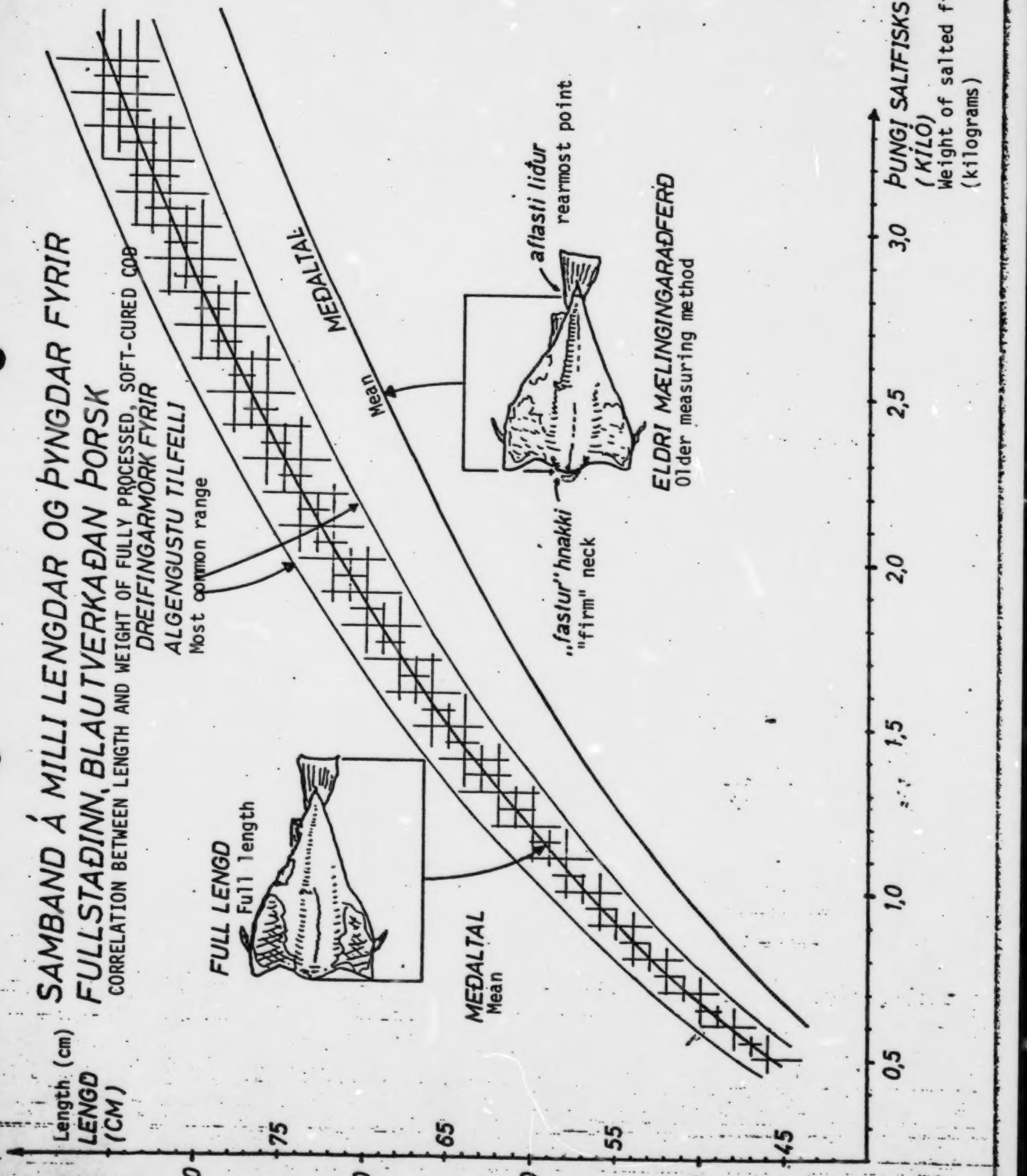
So-called corner marks, consisting of three or four capital letters, show which manufacturer produced the goods, in which part of the country, and in which city, town or village. The Fishing Industry Research Institute allocates marks to the producers. Quality and size categories are marked by figures and letters according to the set system, e.g. 12A.

Date of packaging is shown by a single capital letter. A represents 1-15 January. B represents the next half-month, and soforth, with 24 letters, A to Y being utilized.

Package markings also provide information on product type, generally in English or Spanish, e.g. wetsalted cod, as well as the name of the exporter (Union, Unione). The word Iceland or Reykjavik is also often prominently shown.

Mynd 1.

Figure 1.



3. The markets

3.1. Main consumer countries and the salted fish trade

In previous times, salted fish was exported in dried condition, but production has gradually tended toward fresh cured fish and we are now at a point where over 90% is fresh cured. At the same time, exports have increasingly gone to Portugal which now purchases more than half the total annual output of salted fish and as much as two-thirds in certain years. Table 2 shows exports in the years 1980-1982 by country, while Table 3 shows the distribution of exports by product.

World production of salted (and dried) cod and related products is on average 300-400 thousand tons per annum, with a gradual reduction in recent years. Europe produces about two-thirds of the total, the largest producers in order of importance being Norway, Iceland, Spain, Portugal, the Faroe Islands, France, with other countries producing insignificant quantities. Among producing countries outside Europe, the most important are the U.S. and Canada.

3.2. Markets for salted fish

Iceland's production of salted fish has both increased and changed in recent years. There are various explanations. Besides a number of factors which have their roots in the cod harvest, internal competition between freezing and salting, technological developments in salted fish processing, the economy, and financial affairs within our country, other factors can be found in the market countries themselves.

Consumption of salted fish has been in favour primarily among the catholic countries or regions in Southern Europe and South America where the consumption of meat has been restricted, or even banned, during Lent in accordance with old religious customs. During this period fish is willingly consumed instead of meat in order to avoid the use of animal sources for protein. The same applies to Fridays when fish tends to be offered for sale in preference to meat in the countries mentioned. Although religious customs nowadays generally are less strict, they have created very firm eating habits based on a wide variety of fish dishes. Somewhat similar habits have formed in Greece, although the country is not catholic, but Orthodox Christian.

The market countries are subject to constant change. Little by little, large food retailers are gaining a foothold. Here salted fish is treated differently from the old traditional grocery stores where salted fish was often arranged in piles on the floor, or hung from the ceiling and walls. However, these changes are still very slow and it is difficult to predict how they might escalate. In addition, it is becoming increasingly common in the western world for younger generations to select contemporary foods like chicken, french fries and various universal fast foods such as hamburgers. How one might accustom these generations to time-consuming, but potentially delicious cooking in the traditional manner, is hotly debated.

It is problematical to attempt to sway market preferences and the demand for salted fish according to the requirements of the producing country. It is generally accepted that salted fish is a food of very characteristic taste which panders to strong and very conservative habits. For this reason it is unrealistic to believe that we can directly influence the market. We should rather adapt ourselves and have a positive attitude to the market. In the lucrative markets there is obviously hard competition between Iceland, Norway, Canada and the Faroe Islands, as well as domestic competition in Portugal and Spain.

It is impossible to say how meaningful it is to lay stress on the recovery of markets for fully cured (dried) fish in South America. Considerable import restrictions are now in effect e.g. in Brazil, and the political situation in South America is generally volatile. There are safer markets among the Roman Catholic countries in Europe.

Obviously the seller must always have his eyes open and be quick to respond to changing conditions in order to withstand competitive gyrations. It is important to follow changes in trading habits, consumer preferences, economic conditions, supply and pricing of competitive product, customs tariffs and general business politics. Noone can foretell what specific obstacles might arise in the future.

Table 2: Export of salted fish by country.

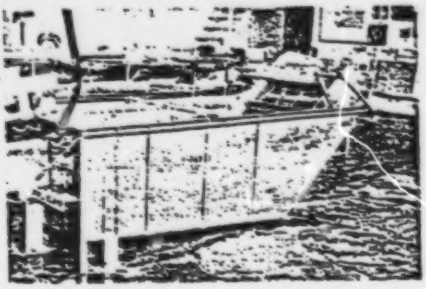
	1980 tons	1981 tons	1982 tons
Total exports:	52,108	59,563	57,878
Total un-cured salted fish:	46,319	56,597	55,111
Britain	298	201	287
France	307	544	1,693
Greece	4,613	3,818	4,178
Ireland	223	122	7
Italy	6,827	2,526	3,477
Portugal	22,183	38,434	36,704
Spain	11,838	9,942	8,740
Other countries/Sea damage	30	1,010	25
Flitches of salted fish, total:	3,250	2,126	1,307
Italy	1,394	528	231
Spain	195	298	250
West Germany	1,614	967	641
Other countries	47	333	185
Dried fish total:	2,539	840	1,460
Brasil	617	266	407
France	322	209	654
Martinique	105	-	-
Panama	185	100	204
Portugal	499	-	-
Zaire	741	186	175
Other countries	70	79	20

Table 3: Export of salted fish by product.

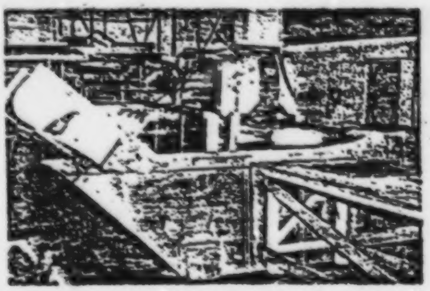
	1980 tons	1981 tons	1982 tons
Un-cured salted fish:	46,319	56,597	55,111
Cod	44,423	53,250	53,377
Black pollack, coal-fish	948	2,561	952
Ling	639	677	717
Flaps of cut-up fish	36	51	45
Other	273	58	20
Flitches of salted fish:	3,250	2,126	1,307
Flitches of black pollack, coal-fish	1,614	967	642
Flitches of cod	1,613	1,131	634
Flitches of ling and tush	23	28	31
Dried fish:	2,539	840	1,460
Cod	900	313	702
Black pollack, coal-fish	475	224	511
Ling	198	72	72
Offal	930	186	175
Other	36	45	-

Myndir frá saltfiskverkun

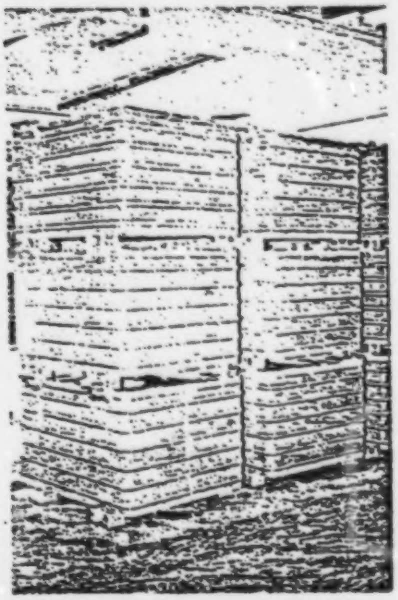
Illustrations of the curing of salted fish



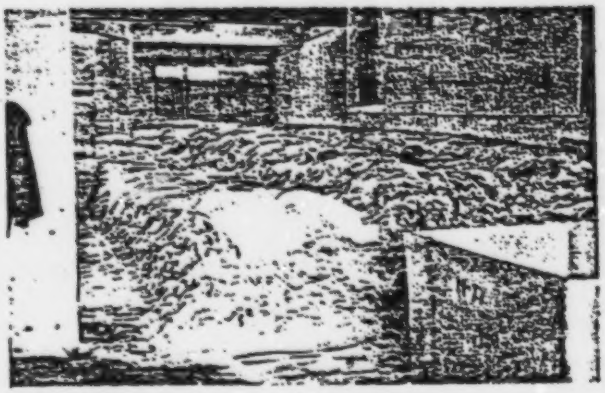
Þvottakar við enda færibands.
Washing tub at end of conveyor belt.



Þvottakar við flatningarvél.
Washing tub at splitting machine.

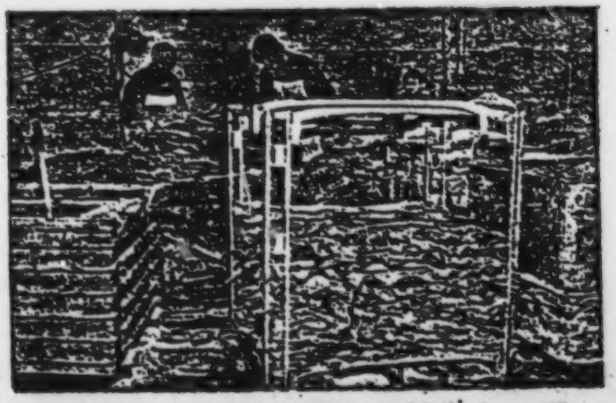


Pækilkörum staflað hvert ofan á annað.
Brine troughs stacked on top of each other.



Saltfiskstæður.
A fish-house for salted fish.

Skriðmót fyrir röðun saltfisks á bretti.
Conveyor for arranging salted fish in trays.



Saltfisk raðað í „brettagám" til stöflunar í saltfiskverkunarstöð.
Salted fish arranged in "tray containers" for stacking during curing process.

4. Code of practice

4.1. General information on salting

4.1.1. The salting process

Salting of fish is intended to induce the following changes:

a) reduction of water content, i.e. dehydration
b) uptake of salt
c) taste maturation or "curing"
d) even thickness, smoothness and satisfactory firmness

Dehydration and salt uptake protect the fish from decomposing and also induce those substance changes in the fish flesh ("denaturation", "curing") which are a prerequisite for the salted fish flavour. To some extent this taste survives even after most of the salt has been soaked out. Pressure exerted in the stacks helps to give the fish an even thickness. The pressure also accelerates the drying process.

There are various methods of obtaining fully processed salted fish (see 2.2.1.) of desirable quality. However, it is not possible to prescribe one optimal method for all salted fish and all raw material. Temperature, salt quantity, salt distribution and salting method, stacking height (pressure), re-stacking frequency and the duration of each curing stage all have an effect on the changes induced by curing. In addition, working practices at each stage have an obvious effect since they vary considerably with circumstances. One cannot define the most desirable or appropriate procedure for all circumstances, unless the condition of the fish is exactly known and it has been decided e.g. whether the fish must be fully processed in order to survive transportation to destination without breaking up or losing weight excessively through loss of water or brine, or whether it can be exported as lightly or medium processed product.

The easiest is to describe the "usual" production practices applicable to "average conditions" and "average raw materials"; however, no exact definitions exist for these two concepts. If circumstances or the condition of the fish are other than "average", the usual procedure must often be modified. In this respect, specific instances will be discussed in sections 4.3 and 4.9 to show what can be done to meet the objectives of better quality and more saleable product.

4.1.2. The production sequence

Diagram 1 shows the "usual" production sequence. However, there are certain variations at each stage. If the catch is landed ungutted, gutting always takes place immediately in the preparation stage. Under current regulations, fish can only be landed ungutted outside the summer fishing season.

Washing procedures vary and the fish is frequently sprayed at the start of the production sequence, i.e. before heading. Brine salting is now the predominant method, while pre-salting in stacks has become less common. Re-stacking frequency varies, although it is generally considered advisable to re-stack the fish at least twice.

Increased temperature generally hastens the curing process, as does pressure in the stack to some extent, provided adequate salt has been able to seep into the fish. The exact duration of each salting and stacking stage cannot be defined. Times shown in diagram 1 are provided for guidance only and presuppose usual temperatures (6-8^{0}C) and procedures designed to produce fully processed fish as defined in 2.2.1.

Lower temperature and low pressure extends the production time for fully processed fish. Insufficient re-stacking or change of trays (as described in 4.9.) results in uneven curing, i.e. part of the fish may not be fully processed even when both sides are adequately cured.

All four changes, i.e. drying, salt uptake, taste maturation and increased firmness, are concurrent and take place gradually during salting and re-stacking. Re-stacking also promotes even moisture content and smoothness. Salt is never quite evenly distributed throughout the stack, and the thick neck sections may lie stacked with little salt in between. Re-stacking rearranges the fish and reduces the likelihood of uneven drying. Also, fish at the top of the stack will be at the bottom of the stack after re-stacking. This makes for equal distribution of pressure and the resulting beneficial effects.

4.1.3. Dehydration and salt uptake

As mentioned, the curing of salted fish involves dehydration, or drying, and salt uptake, the processes being concurrent at least in the early stages. The changes can best be shown diagrammatically. Figure 2 demonstrates the drop in water content and increase in salt uptake in cod salted in stacks at 8°C. It should be remembered that we are discussing standard conditions with little variation; however, the first days are typical of stack salting and not of brine salting. Conceivably, brine-salted fish will need somewhat longer to reach the fully processed stage than fish salted in stacks, but his would probably depend on the properties of the raw material. No ready data is available on this subject.

4.1.4. Premises and equipment for the curing of salted fish

Brief description of working conditions:

Premises for curing of salted fish must be well designed and compact. Ample supplies of good water must be available for the processing. Water consumption is significant in the preparation stages and there is also some need for intermediate washing. The same requirements apply to the preparation area and the processing area in the freezing plant in terms of drainage, lighting, surface treatment of walls and floor, and all outfitting of personnel. Premises used for the curing of salted fish must be insulated so that external temperature shifts have a minimal effect on indoor temperature. Correct temperature is critical during processing and there is an ideal temperature for each stage. The premises are divided into seven sections. These are receiving, preparation, the curing area, the re-stacking area, storage for fully cured salted fish, salt storage, and facilities for personnel.

Each area requires its specific operating conditions. Here we shall deal with lighting and temperature:

	Lighting (lux)	Temperature (°C)
Fish receiving area	300	0.5
Preparation	100-200	10-15
Storage for fish during curing	100-200	5-10
Storage for fully-cured fish	100-200	2- 4
Facilities for personnel	500	

Description of equipment

The fish is gutted by hand and then headed by machine. Heading is carried out so that the flesh at the neck remains in the fish, as well as the collarbones. Often the fish is headed before gutting. This is the case when the catch is landed ungutted and to obtain a better heading cut. After heading the fish goes to the splitting machine. The fish is turned so that the tail enters the machine first, abdomen down, and the knife then slits the fish from the tail forward. The backbone is then removed. From the splitting machine the fish enters a washing tub where it is rinsed in copious amounts of running water. Machines must be designed and placed so as to permit easy maintenance.

Within the salted fish curing house, lifts must be electric or, provided they are very clean, gas-operated. Lifts must be so designed that they do not contaminate the fish, and the wheels of transportation equipment must not be allowed to bring dirt into the fish storage area.

Floors and workers' facilities etc.

The floor must be level, have no cracks, be dust-resistant and made from unimpregnable material. It must be inclined for drainage purposes. Usually the floor is made of concrete or other approved materials.

In production and cured fish storage areas, the slope of the floor must be not less than 1.5:100. In other areas the floor gradient must be at least 1:100.

In premises used for the curing of salted fish, drains must be sufficiently wide and numerous to ensure reliable runoff; they must be provided with water-traps. On average there must be one drain per 40 m^2 or less where floor conduits are used; these must be no more than 10 m apart. Water-traps are necessary to prevent odours and to prevent vermin from entering the fish-house.

Measured in tons, the water requirements are 4-5 times the raw material volume. All drains must be dimensioned for this water volume and should preferably have some additional capacity. Water usage occurs mainly in the production areas. Water outflow from the fish is greatest during the curing period, and is expected to be 40-45 kg of water per 100 kg of raw materials being salted.

Good and well-heated facilities must be provided for personnel. The temperature in working areas tends to be low and it is important that the canteen is well heated so that workers can relax in comfort during coffee breaks. All personnel in the salted fish curing plant must have access to adequate toilet and hand-washing facilities.

Preparation areas require good natural lighting but any windows in the storage areas should preferably be covered.

Distribution of floor area between processing stages

Distribution of floor space in the curing plant is designed to maximise work output as well as conforming to the characteristics of the production process. Restrooms, canteen and cloakrooms for workers must be in a separate area with ventilation to the outdoors. Personnel facilities are a high priority with the workers and tend to affect work output in the plant (see figure 3).

Preparation areas are separated for two reasons, firstly due to the high water usage during preparation, and secondly because the temperature in the preparation area is higher than in the receiving and storage areas. The preparation area should be adjacent to the fish receiving area, but the areas must be separated by an insulating wall due to the considerable temperature difference between areas. The receiving area must be dimensioned for the maximum catch the plant is capable of handling, as well as for the volume of fish likely to require storage in the receiving area in case of build-up of processed product.

The area required for salted fish in the curing stage depends on the output from the preparation area. Brine salting requires four days in the tub, while dry salting after 10-12 days requires an additional 3-4 weeks. The area must therefore be dimensioned for about 15 days' production. Temperature and drainage are critical in this area.

Storage for fully cured salted fish must be refrigerated, the size of the storage area depending on preparation output. Shipping periods also affect the dimensioning of this area. If the same area is used to store packaged and unpackaged salted fish, the salted fish must be stacked on trays to prevent water damage to packaged product.

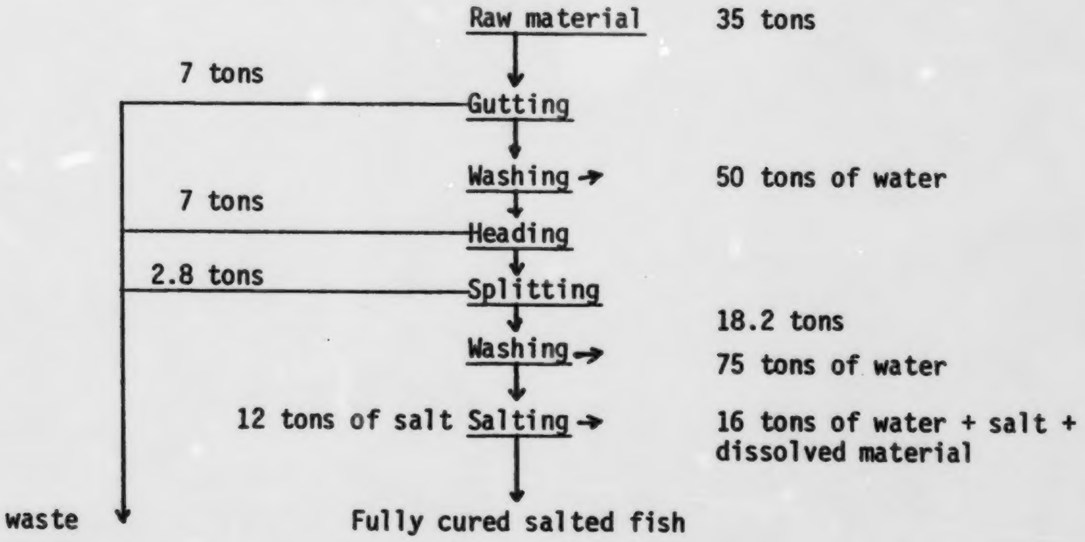
Salt storage must be separated from areas where there is a likelihood of water on the floor to avoid the salt becoming moist. If moist salt is used for salting, its penetration into the fish will be hampered.

To explain the proportioning of floor space in the processing area, and the production flow, one should base calculations on the daily expected production quota. If we assume that the processing plant handles 35 tons of ungutted cod @ 7 kg during 240 production days per annum, processing of the material will follow the path described in overview 2.

Based on the above premises, the processing areas should be dimensioned as follows

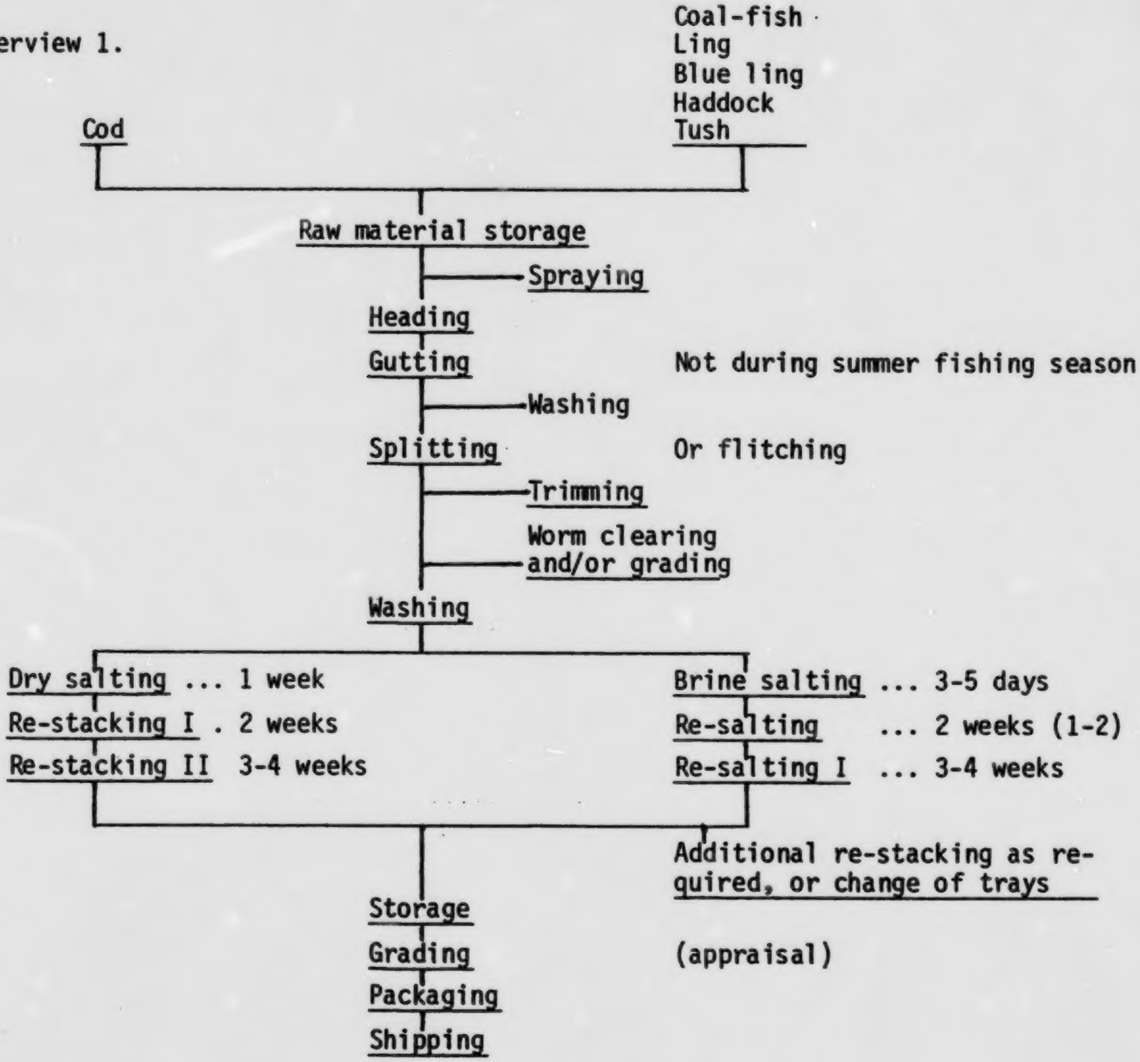
Reception and splitting	400 m^2
Curing storage	1500 m^2
Storage for cured salted fish	100 m^2
Workers' facilities and other space	100 m^2
	2500 m^2

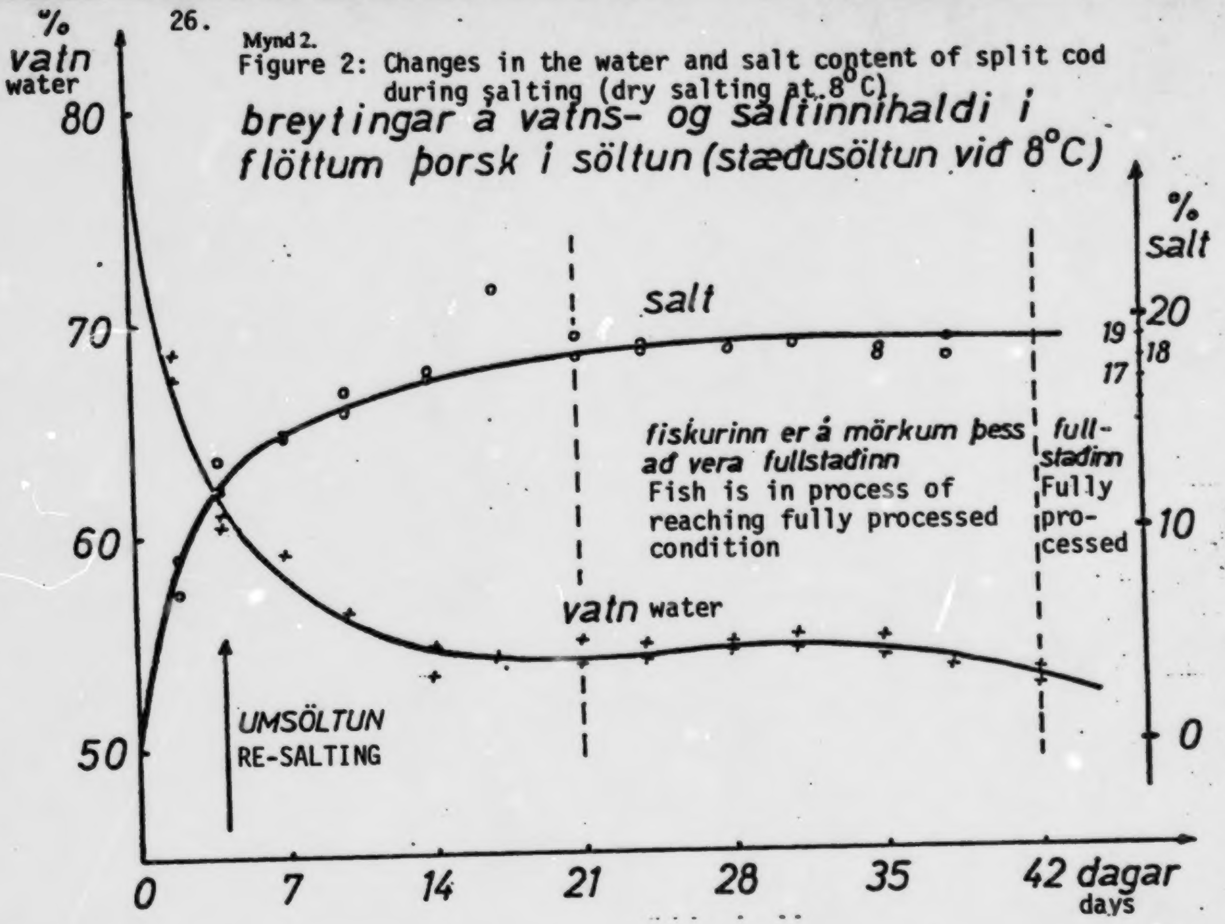
Overview 2: Product flow during salting of 35 tons of fish per day.


Raw material
35 tons
7 tons
Gutting
Washing
50 tons of water
7 tons
Heading
2.8 tons
Splitting
18.2 tons
Washing
75 tons of water
12 tons of salt
Salting
16 tons of water + salt + dissolved material
waste
Fully cured salted fish

GENERAL PRODUCTION FLOWCHART FOR THE CURING OF SALTED FISH

Overview 1.


Cod
Coal-fish
Ling
Blue ling
Haddock
Tush
Raw material storage
Spraying
Heading
Gutting
Not during summer fishing season
Washing
Splitting
Or flitching
Trimming
Worm clearing and/or grading
Washing
Dry salting ... 1 week
Re-stacking I . 2 weeks
Re-stacking II 3-4 weeks
Brine salting ... 3-5 days
Re-salting ... 2 weeks (1-2)
Re-salting I ... 3-4 weeks
Additional re-stacking as required, or change of trays
Storage
Grading
(appraisal)
Packaging
Shipping



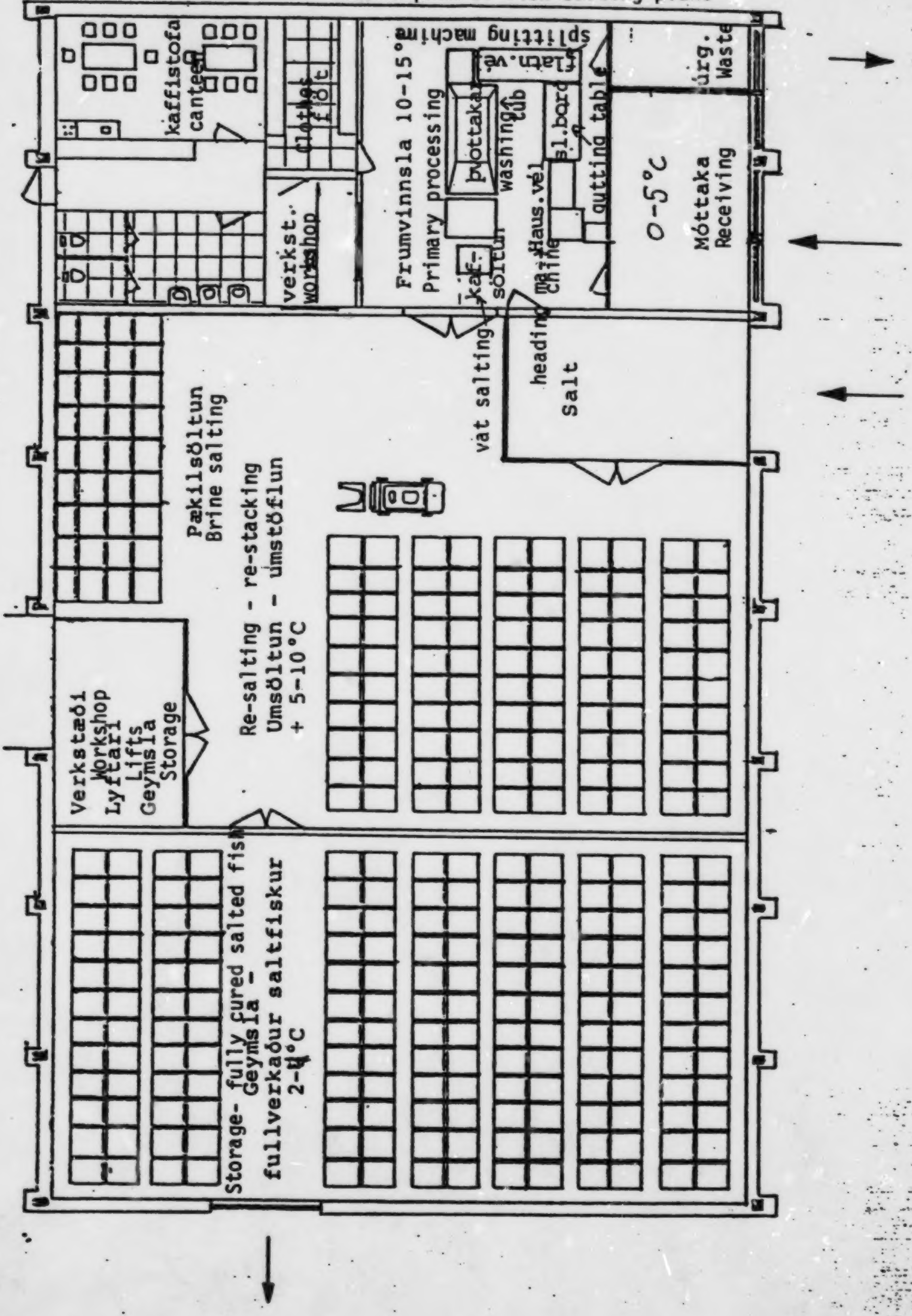
Mynd 2.
Figure 2: Changes in the water and salt content of split cod during salting (dry salting at 8°C)

breytingar á vatns- og saltinnihaldi í flöttum þorsk í söltun (stæðusöltun við 8°C)

UNEDITED TRANSLATION
For information only
TRADUCTION NON REVISEE
Information seulement

27. *Mynd 3.* . Figure 3.

Grunnmynd af saltfiskhúsi
Ground plan of fish salting plant


kaffistofa
canteen
Clothes
föt
verkst.
workshop
Frumvinnsla 10-15°
Primary processing
splitting machine
flatn.vél
þvottakar
washing tub
sl.borð
cutting table
Haus.vél
heading machine
kaf-söltun
vát salting
Salt
0-5°C
Móttaka
Receiving
úrg.
Waste
Pækilsöltun
Brine salting
Re-salting - re-stacking
Umsöltun - umstöflun
+ 5-10°C
Verkstæði
Workshop
Lyftari
Lifts
Geymsla
Storage
Storage- fully cured salted fish
Geymsla -
fullverkaður saltfiskur
2-4°C

4.2. Raw material and its importance

4.2.1. Utilization of raw material

The yield of salted fish varies widely from a given volume of raw material consisting of gutted fish with head or fish from the sea. Relative to the usual final moisture and salt content (52%, 19%) aimed for in soft-cured salted fish, the salted yield of fully processed soft-cured and split cod is in the range of 28% to 36%, based on a packaged overweight of 4% and compared to ungutted fish with head (see table 4). By ranking order, the key factors which reduce the yield are heavy stomach contents (roe, milt, liver, gut contents), volume loss during splitting and heading, and dry salting. The raw material yield improves when stomach contents are light and flesh is conserved during heading and splitting. When variations in salt and moisture content are included, yield variations become still more significant.

Tables 4 and 5 provide an overview of optimal yields and those factors which generally affect utilization.

4.2.2. Quality of raw material

Raw material condition has a decisive effect on the ultimate quality of the salted fish and on yield. It has been said that quality cannot improve once the fish is dead. Changes after death are in one direction only, namely for the worse, but the rate of deterioration depends on circumstances. Factors of most importance to raw material quality include:

a. Feeding and nutritional condition

Fish with a full stomach tend to suffer autolysis damage if not gutted promptly after catching, or if the fish dies in the fishing gear. There is a risk that the stomach may rupture and gastric juices start to digest the belly from within. Refrigeration considerably reduces autolysis.

The nutritional state of the fish affects the robustness and tensile strength (tear resistance) of the flesh. Experiments have shown considerable difference in the tear resistance of cod flitches from one time to another, and from one part of the country to another. However, the correlation between circumstances and tear resistance remains so obscure that no recommendations can be given in respect of harvesting or preparation which might reduce raw material break-up.

Essentially the above deterioration in raw material is defined under breaks and fissures in the salted fish defect grading system.

b. Influence of fishing methods and equipment

A provisional study has been made of defects in Icelandic salted fish. 2,600 representative specimens were randomly selected and appraised at 10 salted fish processing plants and individual defects listed. The fish had been either netted, trawled or caught on a line. The small number of line-caught fish, 192 in all, originated from a single processing plant. Results are shown in Table 6. Netted fish were caught during the spring fishing season, while trawled fish were caught either in spring or summer. Line-caught fish had been harvested in autumn.

As expected, line-caught fish provided the best results but were landed ungutted. Most defects were bleeding or breaks and fissures. No detailed analysis was possible of the various types of bleeding damage.

The comparison between netted and trawled fish is noteworthy, although some of the trawled fish came from floating warps while the bulk had been caught in trawl nets. Trawled fish fared worse than netted fish relative to the grading scale. Netted fish showed fewer raw material defects in all categories except autodigestion, which was conspicuous in netted fish and caused by the fish dying in the net. Generally, bleeding was more frequent in trawled fish, usually because of excessive delay in gutting onboard the trawler or because of bleeding fissures. However, poor washing procedures can also cause bleeding damage. The rate of bleeding damage varied much more in netted fish (between 13% and 73%) than in trawled fish (15% to 42%) where the rate of bleeding damage was more constant. Trawled fish also showed more breaks and fissures than netted fish, as well as other raw material defects which generally fell into the category of storage damage. Obviously, storage damage also occurs in the raw material storage area of the fish processing plant. It is conspicuous that most defects are linked to the quality of the raw material. Yet this is not the only cause of defects. Breaks and fissures increase with the compression both in the fishing equipment and in storage; however, the characteristics of the fish in its ocean environment is also responsible, as indicated above.

Heading damage tends to be disappearing, but may occur in considerable numbers in isolated instances. Splitting damage generally ranges between 3% and 14%

with an average of 5%; there is always some. Other processing damage is disappearing, except salting damage which sometimes occurs.

c. Treatment on-board fishing vessels and transportation equipment

Bleeding of the fish is very important as clearly shown in Table 6. If the fish has been bled after death, the full extent of raw material damage usually shows in the yield of salted fish. The same applies to fish with bleeding fissures. Experiments have shown that bleeding troughs come in useful if the fish is compromised or not alive when bled. Bleeding damage is usually obvious in the raw material.

If gutting is delayed, there is a tendency to autodigestion of the stomach. This is especially the case if temperature is high and the stomach contains much food. Careless gutting will lead to bacterial growth from the gut in the stomach cavity and neck, resulting in further damage.

Storage damage is caused by extended storage periods or lack of proper refrigeration. Such damage usually affects salted fish, if not as serious damage, then as unfavourable colour changes or even odour.

Rough handling on-board and during transportation causes breaks and fissures as well as serious damage if the raw material is squeezed or torn.

4.2.3. Raw material grading and quality guidelines

The condition of the raw material has a deciding impact on the ultimate quality of the cured salted fish. In addition, proper grading of the raw material is clearly important for appraising its quality in a reasonable manner.

Correct grading of raw material in the raw material storage area awaiting processing into cured salted fish is important for the following reasons:

a) To decide whether the fish (raw material) or only part thereof is suitable for processing into cured salted fish.
b) To determine whether the raw material can be maintained in storage, or whether special arrangements should be made for immediate processing, possibly on overtime.
c) To control production on the basis of raw material characteristics.

d) To determine when fully cured salted fish is ready for packaging, as well as the curing time required to reach fully processed condition.
e) To assess the quality grade or condition of goods produced.

Main raw material defects and their consequences

Inescapably, most raw material defects show up in fully cured salted fish, whether it be soft or dry cured. However, when raw material defects appear in fully processed product, they vary in severity depending both on the type of defect and on the processing, which is an important factor. Processing can accentuate or increase a defect as well as reduce it, or its visible consequences. Generally, all the most common and severe raw material defects show up fully in the final product. Mention should be made of breaks, bleeding the fish after death, autolysis, bleeding fissures or cracks, as well as maltreatment or tears in the flesh and storage damage. An overview of the most common raw material defects and their importance for product quality is shown in Table 7.

Fresh fish grading system applied to salted fish processing

With regard to the most important raw material defects found in Icelandic salted fish, the special appraisal system developed for the salted fish industry is mostly used. These generally written appraisal directions for grading defects in fresh fish only partially cover those raw material defects which adversely affect the value of Icelandic salted fish.

Generally, bacterial and biochemical processes cause both storage damage and to some extent breaks and fissures in salted fish, but do not lead to other serious damage such as bleeding, autolysis, or breaks and fissures arising primarily from causes other than bacterial decomposition.

The following appraisal scale provides direction for the grading of raw material for the salted fish industry (Table 8).

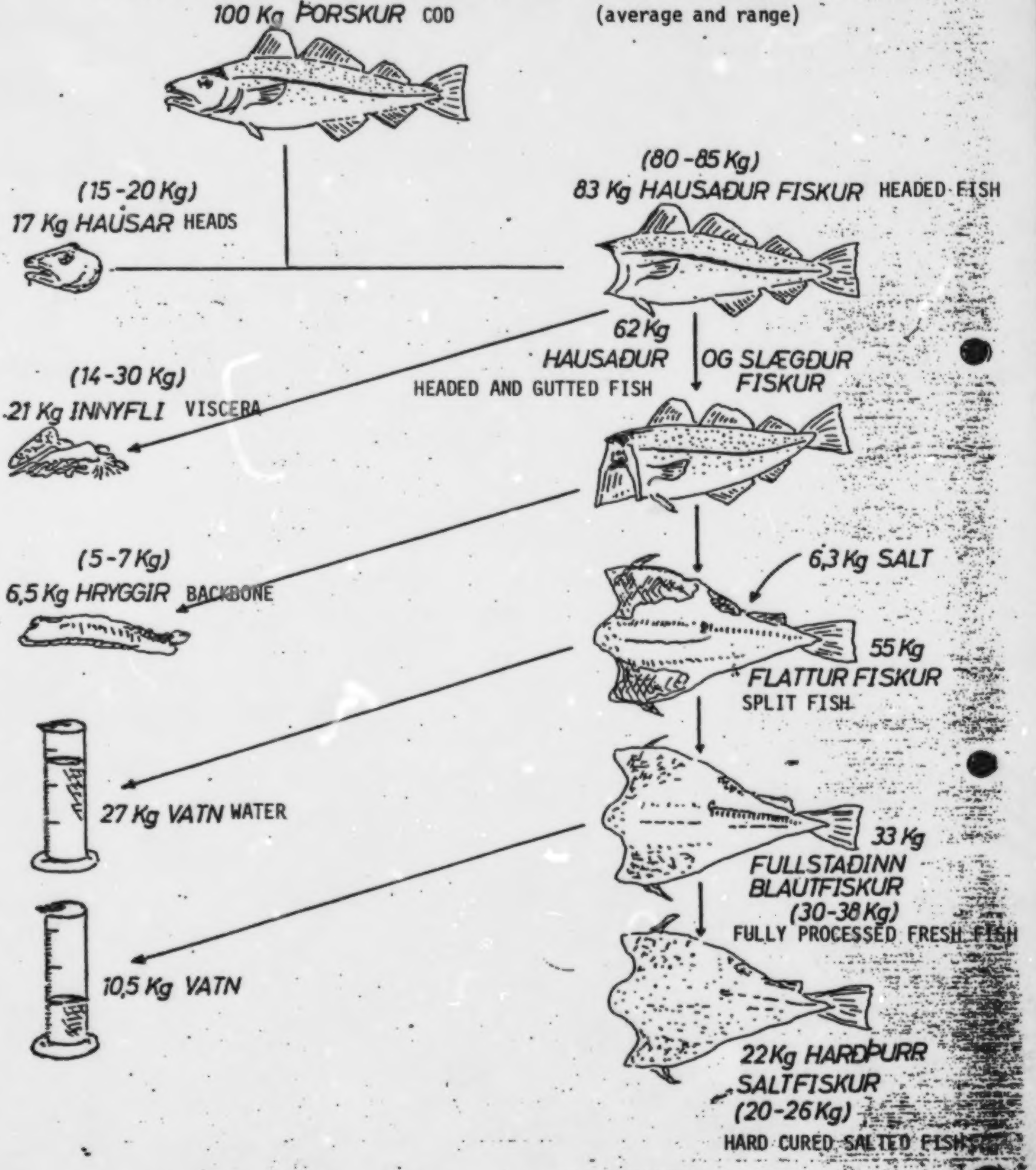
There is no direct correlation between the raw material grading scale and the quality grades applied to salted fish. However, the raw material grade provides an indication of the potential quality achievable in the salted fish based on usual salting procedures and uneventful curing.

32.

EFNAHLUTFOLL OG NYTING Í SALTFISK-VINNSLU (meðaltöl og sveiflur)

DISTRIBUTION AND UTILIZATION OF RAW MATERIALS IN THE PROCESSING OF SALTED FISH

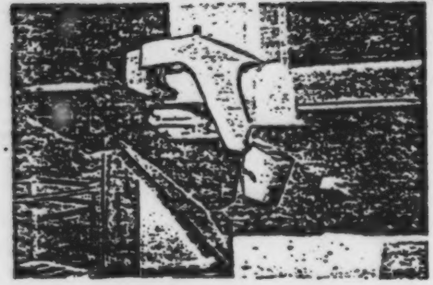
(average and range)


100 Kg ÞORSKUR COD
(80-85 Kg)
83 Kg HAUSAÐUR FISKUR HEADED FISH
(15-20 Kg)
17 Kg HAUSAR HEADS
62 Kg
HAUSAÐUR OG SLÆGÐUR FISKUR
HEADED AND GUTTED FISH
(14-30 Kg)
21 Kg INNYFLI VISCERA
(5-7 Kg)
6,5 Kg HRYGGIR BACKBONE
6,3 Kg SALT
55 Kg
FLATTUR FISKUR
SPLIT FISH
27 Kg VATN WATER
33 Kg
FULLSTAÐINN BLAUTFISKUR
(30-38 Kg)
FULLY PROCESSED FRESH FISH
10,5 Kg VATN
22 Kg HARÐÞURR SALTFISKUR
(20-26 Kg)
HARD CURED SALTED FISH

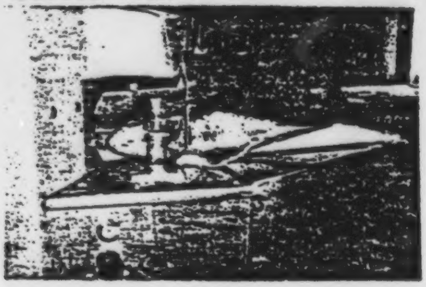
Saltfiskvinnsluvélar

33.

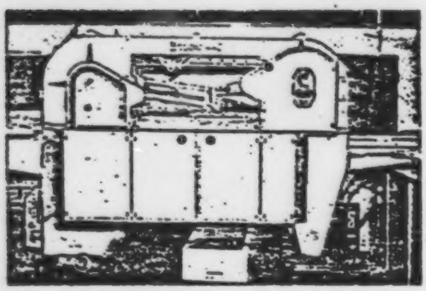
Processing machinery for salted fish



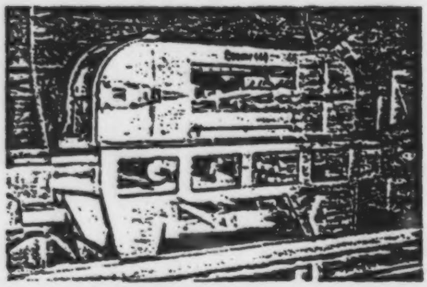
Baader ÍS 001 hausunarvél.
Baader IS 001 heading machine



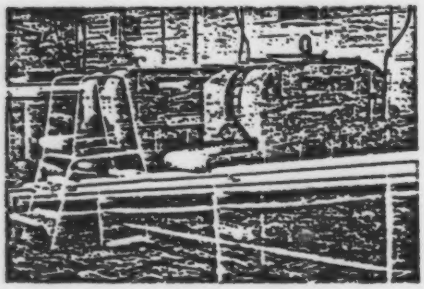
Ræsiarmur Baader ÍS 001 í kverk þorsks.
Gutting arm Baader IS 001 in the throat of a codfish



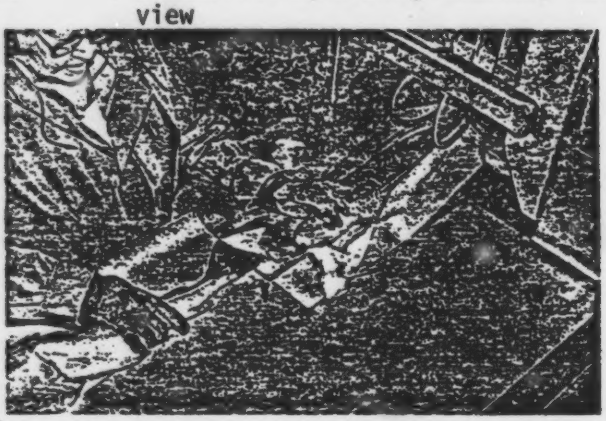
Baader 440 flatningarvél, hægri hlið.
Baader 440 splitting machine, right view



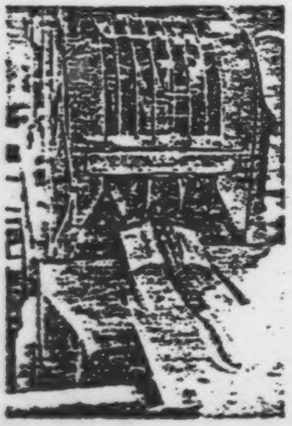
Baader 440 flatningarvél, vinstri hlið.
Baader 440 splitting machine, left view



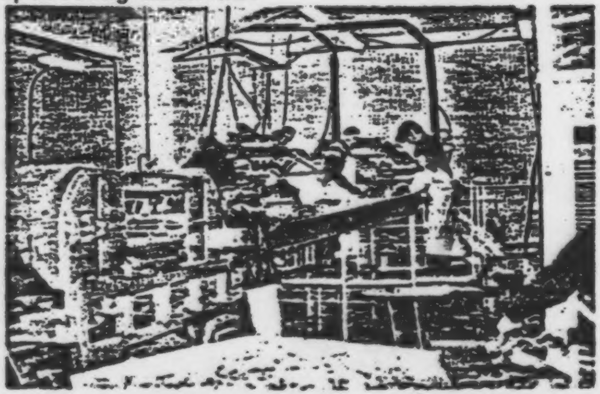
Flatningarvél við færiband, sem flytur flattan fiskinn frá vélunum til þvottakars.
Splitting machine at conveyor moving split fish from machine to washing tub.



Fiskur lagður rétt í trog flatningarvélar.
Fish correctly positioned in the trough of splitting machine.



Trog á flatningarvél.
Trough of splitting machine.



Séð yfir aðgerð og mötun flatningarvélar.
View of maintenance and feeding of splitting machine.

Table 4: Distribution and utilization of raw cod in salted fish production.

Product (or fish segment)	Distribution in %: Mean	Range	Selected reasons for: lower percentages	higher percentages
Head	17%	(15-20)	Feeding fish, caught in season	Immature fish, Summer catch
Roe and liver	12%	(9-15)	Small fish	Caught in season
Other viscera (bladder & milt)	9%	(5-15)	Summer catch	Feeding fish, caught in season
Backbone	6-7%	(5-7)	Caught in season	Small fish, summer catch
Split fish	55%	(47-60)	Caught in season	Summer & autumn catch
Fully processed salted fish (52% water, 19% salt)	33%	(30-38)	Caught in season	Summer & autumn catch
Portugal dry (40% water)	26%	(24-30)	Caught in season	Summer & autumn catch
Extra dry (30% water)	22%	(20-26)	Caught in season	Summer & autumn catch

Table 5: Some proportionate utilization figures.

	Method of calculation	Common numbers (Most common numbers)	Selected reasons for: lower percentages	higher percentages
Heading loss	$\frac{\text{weight of head x 100}}{\text{weight of gutted fish w/head}}$	20-24% (21-23)	Trawled fish Headed by hand	Netted fish (caught in season), machine headed
Splitting loss	$\frac{\text{weight of back x 100}}{\text{weight of gutted \& headed fish}}$	8-11% (9-10)	Trawled fish, split by hand, splitting machine well adjusted	Netted fish, machine split splitting machine poorly adjusted
Utilization of gutted fish	$\frac{\text{weight of gutted fish w/head x 100}}{\text{weight of fish from ocean}}$	76-48% (79-81)	Caught in season Feeding fish	Trawled fish Line-caught
Utilization of split fish	$\frac{\text{weight of split fish x 100}}{\text{weight of gutted fish w/head}}$	68-72% (69-71)	Netted fish, machine split, splitting machine well adjusted	Trawled fish, split by hand, splitting machine poorly adjusted
Total utilization	$\frac{\text{weight of split fish x 100}}{\text{weight of fish from ocean}}$	48-59% (55-57)	Netted fish, machine headed and split	Trawled fish, hand headed and split
Utilization when salted: (52% water, 19% salt) 4% packaged overweight	$\frac{\text{weight of salted fish x 100}}{\text{weight of gutted fish w/head}}$	36-46% (40-44)	Dry salted Bled live Machine headed & split	Brine salted Bled after death Hand headed & split

Table 6: Defects in salted fish relative to harvesting method.

	Netted fish	Trawled fish	Line-caught fish
Number of specimens	1672	794	192
Quality grade I	42.8%	26.9%	68%
Quality grade II	16.4%	25.3%	21%
Quality grade III	27.2%	42.2%	8%
Quality grade IV	11.3%	4.4%	3%
Quality grade V (waste)	2.2%	2.2%	0.5%
Catch landed	ungutted	gutted	ungutted
Total defects (% of fish with defects)	56.7%	74.3%	35%
Bleeding damage	21.1%	29.0%	15%
Autodigestion (autolysis)	9.8%	0.1%	0.5%
Other raw material damage	4.9%	17.0%	0.5%
Breaks and fissures	13.2%	20.0%	9%
Total raw material defects:	49.0%	66.1%	25%
Heading damage	0.1%	0.4%	5%
Splitting damage	3.5%	6.4%	5%
Trimming damage	1.2%	0.4%	0%
Salting damage	2.7%	1.0%	0%
Other damage	0%	0%	0.5%

Table 7:

Correlation between defects in raw material and salted fish.

Main raw material defects	Salted fish defects	Typical defect weighting in grading of salted fish
Breaks, (broken in pieces)	Breaks	III(II)
Breaks, (broken in pieces)	Fissures	III(II)
Bled after death	Blood vessels in flaps	II(III)
Bled after death	Dirty colour	II
Bled after death	Blood on back at tail	I
Autolysis	Autolysis	III(II)
Fish with bleeding fissures	Fish with bleeding fissures	III(II)
Spoiled in storage	Storage defects (yellow-brown colour)	II
Spoiled in storage	Breaks	III(II)
Spoiled in storage	Frost damage	II(III)
Spoiled in storage	Blood at neck (neck shows blod clots or colouring)	II(III)
Mis-handling/hook marks	Bruises	II(III)
Mis-handling/hook marks	Pools of blood	II
Mis-handling/hook marks	Fish torn	III
Mis-handling/hook marks	Fish squeezed	III

Table 8: Grading scale for raw material quality. Fish is appraised after splitting (flitching).

Grade	Condition of flesh	Blood colouring in flesh	Autolysis damage and blood in flaps	Bacterial damage
1	Muscle tissue intact and free of breaks.	Flesh light and normal in colour.	No autolysis damage.	Aroma is very fresh (seafood smell).
2	Muscle tissue mainly intact and without broken or missing segments.	Fish flesh is more reddish or darker than normal.	Insignificant autolysis damage and dull blood vessels.	Aroma is fresh and normal.
3	Significant breaks and missing segments also affecting main sections of flesh.	Flesh has some conspicuous blood-stained areas.	Considerable autolysis damage and prominent veins, but no joined blood spots.	Fish smell has dulled but there is no unnatural odour.
4	The main sections of flesh are cracked and broken apart.		Massive autolysis and joined blood spots.	Fresh smell mainly lost. Unnatural odour starting to appear (defrosting smell, heavy fish odour).
5				Sour or putrefying odour is manifest.

4.3. Storage of raw material

Fish awaiting processing for some time must be stored gutted and adequately iced in the raw material storage area of the processing plant at a temperature which does not rise above 0°C or the 0-2°C range. Fish may be stored either in boxes, containers, or loose on the floor which must have sufficient slope to ensure proper water drainage from the fish containers. Containers must not be too deep (maximum approx. 60 cm) in order to prevent pressure damage. Ice must be scattered around all the fish to ensure that the temperature at no point rises significantly above 0°C. The fish should be taken into processing as soon as possible since the yield drops with storage, and storage damage sets in quickly.

Experiments have shown that compared to fresh fish, iced fish gives an almost 4% lower weight yield after salting (salted yield) after 7 days' storage on ice in containers, and fully 5-6% lower yield after 13 days' storage on ice. These figures represent fully processes salted fish as a percentage of fresh gutted cod. Some of the raw material loss comes from the draining of fish in storage; in addition, stored fish diminishes more than fresh fish upon salting. Depending on circumstances and the raw material, the reduction in salted yield may vary up or down compared to the percentages shown.

Experiments have also shown that the quality grade of salted fish drops steadily the longer the raw material is stored on ice. Those defect which particularly affect trawled cod stored on ice include darker colour (storage defect) and breaks. As stated before, numerous factors affect the outcome and we can only point to the probability of negative effects arising from storage during a given period.

Risks:

1. Storage damage will appear very rapidly and become serious within a few days of storage if:

a) The fish is poorly washed after gutting and intestinal bacteria are allowed to contaminate the entire fish.

b) The fish has been contaminated on board the fishing vessel or in the transportation vehicle.

c) Temperature has risen significantly above 0°C in the entire fish, or parts of it, due to insufficient ice or uneven distribution of ice in conjunction with high temperature in the raw material storage area.

d) Gutting has been inordinately delayed and autodigestion damage has not been arrested in time. The risk of autodigestion damage also depends on the feeding state of the fish, i.e. the type and quantity of food contained in the gut.

2. Breaks and fissures increase in salted fish if the raw material has been stored for a prolonged period. Storage conditions also have an effect, i.e. temperature and mishandling.
3. The salted yield drops steadily with the length of storage. Under optimal storage conditions the yield (salted yield) drops by about .5% daily on average, and more if conditions and raw material are sub-optimal.

4.4. Heading

4.4.1. Machine heading

General information on heading of fish for salting

Machine heading has established itself in recent years and heading by hand has now become quite rare. The most common heading machine or "header" is the so-called Oddgeir header which has been in use for about fifteen years. Some 300 such machines have been manufactured and most of them remain in operation. The heading machine is designed for salted fish and stockfish production, but all common codfish species under 80 cm in length, or even larger, can be headed in the machine.

The Baader 414 header was common earlier and was sold into the seventies. This machine has now been banned in its original design because of the risk of accidents, but in other respects it performed well. A new machine is now offered for sale by Baader and has been designated the ÍS 001. Production of this header started at the beginning of 1983. Like its two predecessors it is designed for salted fish and stockfish production. The ÍS 001 heading machine will head all common codfish species ranging in size from 50 cm to about 110 cm total length. According to the manufacturer the size of the fish is of little importance.

Operating information on heading machines

The Oddgeir header:

Measurements: length 2.8 m, width 1.5 m, height 1.8 m.

Output: Approx. 28-38 beheadings per minute

The conveyor is powered by a 0.5 horsepower electric motor and the knife by a 2 horsepower electric motor. The heading machine rests on a steel framework which stands on the floor, supported by three feet which are secured to the floor.

The heading procedure requires the fish, gutted or ungutted, to be placed on a conveyor which moves it to the heading knife. On the conveyor there are ledges or supports on which the fish is placed belly up. The conveyor moves the fish under the guide irons which grip the fish at the throat and guide it to the knife, holding it in position while the head is being severed. The guide iron is divided, its upper section also serving as a safety cover. The severed head is drawn away by a hook at its end, referred to as a ripper. The purpose of the ripper is to grip the head if it has not been completely severed from the trunk. The beheaded fish then moves forward with the conveyor and drops off onto a slide or conveyor. The head falls onto a slide which leads to a conveyor or container, as circumstances require.

The heading machine operates at a set speed which brings 28 fish per minute under the knife. It is possible to increase the speed by changing the ratio between the driving chain gears. It is also possible to increase the number of ledges on the conveyor without increasing its operating speed.

The knife consists of a sharp disk which revolves, powered by a 2 HP electric motor. It is important that the knife is sharpened regularly since a blunt knife will cause a ragged neck cut as well as squeezing the fish.

A water jet is directed onto the fish in order to keep it clean and free of membranes and bones which prevent a clean cut.

Baader IS 001.

Measurements: height 1.5 m, width 1.4 m, depth 1.0 m and weight 200 kg.
The header stands on four feet on the floor.

This heading machine handles both gutted and ungutted fish from 50 cm up in length. Heading is carried out in the following manner. The fish is turned with its left side up and its belly toward the machine operator and is placed on a special operating arm which enters the throat between flap and head. The fish is moved forward into the machine by the operating arm which is lodged in the above position and which then activates a special fork which grips the fish between head and flaps and guides it in the direction of the knife. At the same time the back of the fish is laid against the back plate which supports the fish during the heading procedure. The knife is a sharp revolving disk. The headed fish and head drop off the heading machine onto slides. One worker attends the heading machine which operates at a constant speed. It is possible to range the fish on the machine, i.e. the operating speed is not controlled by the machine but by the pace of feeding maintained by the machine attendant.

Water sprays on to the knife from a tube which also serves as a protective cover for the knife. This keeps the knife clean and wet and facilitates a clean heading cut.

The moving parts of the machine are covered by a housing. When the housing is raised, current to the machine is disconnected.

Heading damage. The most common heading damage (see Table 9) includes:

3. Fragments of the gills remaining. Heading is incomplete due to incorrect setting of the machine.
4. "Crumbs" adhere to the neck. The fish was not properly placed in the header.
5. Flaps are separated from the neck: The knife cut too far back in the fish.

Damage of types 3 and 4 is generally not serious since it can be corrected by trimming during flitching or packaging. On the other hand, damage of type 5 is more serious because it loosens the wet bone, causing a defect which cannot be remedied in the salted fish. In addition it means that the head will have been severed too far back, thus again reducing the yield by a few percent or causing the defect known as "stung neck" on fully cured salted fish; cf. the defect grading scale. A blunt knife squeezes the neck and then produces a ragged cut.

Generally speaking, heading defects occurring with the Oddgeir header are related to the manner of working of the individual placing the fish on to the machine. On the other hand, the manner of working is influenced by working conditions at the plant, the knowledge and skill of its workers, and their working pace, as shown in our example. The characteristics of the raw material tell us less about heading damage than the manner of working when attending the machine.

The new Baader heading machine is a more complex and heavy-duty piece of equipment. It will repay a high degree of accuracy on the part of the worker feeding the machine and experience will show whether rough treatment or wear will reduce its excellent heading quality if something unforeseen occurs. There are some indications that this header will affect yields positively because of better neck cuts than we have seen in Iceland with previous heading machines.

Adjustments, maintenance and repair of heading machines

Oddgeir header:

Knife: Sharpen at 10-15 day intervals or as required. Repeated sharpening reduces the size of the cutting disk and increases the distance between base plate and the bearing in the knife shaft. The smooth side of the knife should be turned towards the head of the fish.

Conveyor: The conveyor belt must be properly tensioned and is normally gripped by its underside.

Guide irons: The elevation of the guide iron is adjusted by screws. The proper setting requires a distance of 3 cm between the guiding bar and the spikes on the support.

Lubrication: The lubricating points (conveyor etc.) should preferably be serviced daily if the machine is in regular use. Processing plants must have a heading knife on hand.

Baader IS 001:

Operating arm: Separate arm adjustments are required for gutted fish and fish which is merely bled. The same setting will not work for both.

Back plate: The back plate controls the cutting angle for the heading cut, and in the process controls the yield.

Initially, the back plate should be adjusted with the screws provided so that the cut is optimal and yields will be as high as possible. The setting must be changed for processing of haddock, since haddock has a shallow throat. When processing is changed back to cod or other species, the back plate must be re-set.

Arms: These are adjusted by separate controls and affect the fish dropping off the back plate. Controls should be adjusted at the outset and when circumstances require.

Special instructions are required for making adjustments to the machine. Spare knives must be available. Grease nipples must be serviced regularly or as required.

There is a cover over the moving parts of the machine and all current is disconnected when the cover is raised.

The heading machine knife

Tending the knife is a very important matter and often there is a firm rule to sharpen it daily. It is advisable to have at least two knives in use and exchange the knife when blunt for the newly sharpened. Holding screws unscrew in the same direction as the rotation of the cutting disk. Poorly sharpened knives cause many defects and much inconvenience. The cut becomes ragged and the fish is squeezed during heading. The headed yield deteriorates, i.e. heading loss becomes too high. Generally speaking, heading of ling and tush take more out of the knife than cod, haddock or coal-fish. Precautions against hooks must be taken when heading line-caught fish.

There is no generally accepted rule as to the frequency of sharpening. A common guideline is to sharpen it after a maximum of 50 tons of fish has been headed. Heading knives require more frequent sharpening than e.g. knives in splitting machines.

4.5. Gutting and splitting

4.5.1. Gutting

Fish may be gutted before or after heading. If the fish is landed gutted, gutting will have taken place at sea after bleeding. Often the fish is bled and gutted at the same time, and it is not entirely clear what the effect is of delaying the gutting until the fish has been bled. The most important factor is the proper washing of the fish, especially if it was bled after death. The fish is slit from the midpoint of the belly back to the anal opening. This is especially important for the curing of salted fish. It is more difficult to make a regular cut at the midpoint of the belly if gutting takes place on land since it is usually done with the fish lying on its side on a table constructed for heading purposes. Coal-fish must be slit beyond the anal opening and all other species to the anal opening.

4.5.2. Splitting by machine

For the most part splitting is carried out by machine and almost every processing plant has acquired a splitting machine. There is only one model available, the Baader 440. The thickest fish must still be split by hand; this usually applies to fish longer than 110 cm.

The Baader 440 has been used in Iceland since the late sixties and some 150 machines are now in operation. Among them are a few which are approaching a quarter-century of use.

It does not take long to learn how to operate the machine and a worker will be thoroughly expert within a week. The splitting procedure starts with the fish being placed in a special trough at the end of the machine with the tail first and belly down. It is important that the flaps are spread open before the supports on the trough. The fish is then pushed into the opening in the machine where the tail clip grips it around the tail fin, drawing the fish through the machine. The fish is first drawn to the splitting knife which slits it from the base of the tail along the main bone to the blood vessel. The bone stripper now comes into action, consisting of a pair of knives which sever the back at the blood vessel and the cut out the backbone to the head end of the fish. At the end the fish emerges from the machine on the conveyor.

The machine operates at a constant speed of 25 fish per minute. One person is required to arrange the fish on the machine and ensure that the fish are turned towards the attendant, i.e. the tail is turned into the machine.

Baader 440 splitting machines handle cod, coal-fish and ling.

Adjustments, maintenance and repair.

The most common spare parts required are: Knife # 132 (2 each), knife # 511 (?) (1 only), bolts # 440.04.60 (4 each) and 440.12.45 (3 each) as well as spring # 202.

The Baader 440 splitting machine handles headed and gutted fish. It is important that the fish has been correctly gutted, i.e. slit in the abdomen. The incision must be in the middle of the belly by a straight cut of sufficient length.

This applies to all species of fish. If the cut does not extend sufficiently far back, there is a risk that the flaps will hang together. All fish must be slit back to the anal opening, except coal-fish which must be slit still further back to the front anal fin. It is important that coal-fish are slit close to the right side of the anal fin. If the cut is on the left side, the appendix will remain in the fish after splitting and must then be removed during flitching and grading.

Care should be taken that fish is not placed in the machine during rigor mortis.

If the fish placed in the machine is too small (approx. 50 cm in length) the risk is that the initial cut will be too shallow and the back severed too far forward causing bleeding in the spine, as well as the fish being cut through the skin in boneless areas.

The machine works by the tail clip gripping the fish by the tail fin. When splitting smaller fish, or ling or tush, a special plate must be placed in the trough in the opening to the machine. This raises the fish in the trough and permits the tail clip to obtain a better grip on the fin.

If too large a fish is placed in the machine it is primarily the thickness of the fish that may cause problems. The feed chain in the machine can go out of control, damaging the knives. If too large a ling is placed in the machine, the tail clip may lose its grip before the splitting procedure is completed, i.e. before the cut is sufficiently extended forward.

When the fish passes through the machine it first comes to the splitting knife. The splitting knife cuts from the tail to the blood vessel, i.e. to the middle of the anal fin of cod. If the splitting incision extends too far, there is a risk of blood spots appearing at the base of the backbone. By adjusting the splitting knife control cam one can control the length of the splitting cut, i.e. the point where the knife drops down.

After passing the splitting knife the fish arrives at the bone stripping knives, which start by severing the back at the blood vessel and then cut out the backbone to the head end of the fish. A separate control cam is used for the bone stripping knife and must be set so that the back is severed just behind the blood vessel. Blood spots will otherwise appear at the root of the backbone near the tail.

Special guides are also used for adjusting the bone stripping knives in order to determine the depth of the stripping cut. If too much flesh is cut away with the backbone, yield is affected, and if the cut is too close there is a risk of air bladder spots in the fish after splitting.

Plastic guides control the amount of pressure exerted on the fish by the bone stripping knives. Settings are controlled by a roller lever. The roller lever has a hook at the end which may wear out, in which case the backbone will be cut out of the fish all the way back to the tail.

In many respects knives in splitting machines require the same treatment as in heading machines.

The Baader 440 splitting machine has three knives in all, the splitting knife and two identical bone stripping knives. When loosening the splitting knife and one of the two bone stripping knives it should be noted that they are secured by nuts with left-hand thread. The nuts are loosened by turning them in the same direction the knife turns when the machine is operating. When mounting the bone stripping knives, the smooth side should be turned up. Upon repeated sharpening of the back stripping knives they will reduce in size and one must take care that the clearance between them does not exceed 1 mm, in which case the washer must be removed. If the clearance between the knives is too wide, the backbone may be torn out instead of cut out.

If knives are not kept sharpened, the following problems will occur: an increase in unnecessary quality loss; increased fissures and breaks; stretching of the fish flesh; the risk of the splitting knife not starting to cut farthest back at the tailfin and the tail area remaining partly closed. One should aim to sharpen the knives after 100 tons have been processed by the machine, unless a daily sharpening routine is in place.

When processing line-caught fish one must ensure that no hooks enter the machine with the fish. Hooks can damage the knives and other moving parts.

The machine requires daily cleaning and it is especially important to clean under the cover over the bone stripping knives.

After cleaning, the machine must be lubricated and it is important to service every nipple. The drive mechanism for the bone strippers must also be greased and oil added to the automatic lubrication dispenser, if one is fitted. Detailed instructions are found in the lubricating chart accompanying the machine.

Special operating instructions are provided by the manufacturer and every machine owner should have a copy available for use by machine operators and supervisors.

4.5.3. Splitting by hand

Splitting is initiated by cutting open the fish along the crest of the front side (right side) from below, leaving the fish closed at the "back of the front side". The backbone is removed (from the 3rd joint before the anal opening on cod) by cutting it free on both sides and then severing the bone by an oblique cut at the aforementioned point. In the illustrations demonstrating the procedure, another working method used in Iceland is shown. It differs in that the worker cuts away from himself, and not toward himself, once the initial belly cut has been made. This method may be more difficult due to the risk of cutting too deep.

4.6. Most common preparation and production damage

A study was made at 10 salted fish processing plants to determine the most common defects occurring in split fish after preparation and splitting. Conclusions are shown in Table 9 where the frequency of each defect is denoted separately as a percentage. In general there were defects in one-third to two-thirds of all split fish when raw material defects were included. If only heading, preparation and splitting defects were counted, the rate was between 25% and just over 50% of fish.

Heading defects: Often these are almost non-existent in terms of remaining gill fragments and "crumbs". The main explanation of heading defects is inexperienced operators working the header (Oddgeir, B 414). By ranking order, "crumbs" and "flaps loosened from the neck" are the most common defects, the latter causing a serious defect in salted fish. As an example, "loose flaps" reached 18% in one instance.

The new heading machine B IS 001 provides faultless heading if it is carefully adjusted. As previously discussed, the heading yield is a matter of considerable importance.

Preparation damage: Most preparation damage, which varies widely in frequency, is not serious and can mostly be remedied by trimming. However, this does reduce the yield. More serious damage is caused by fragments of liver and intestine if allowed to remain in the fish during salting. Also, if the collar bone protrudes from the flap the defect becomes serious since it cannot be repaired. This defect i.a. arises from incorrect bleeding; the bleeding knife cuts off the skin from the collar bone, making it protrude from the flap. Extensive or poor storage of the raw material is also a cause of exposed collar bones.

Preparation damage first and foremost reflects working methods during bleeding and gutting, while the heading procedure contributes to the problem of loose flaps. If the flap is gripped roughly during gutting, it will come loose.

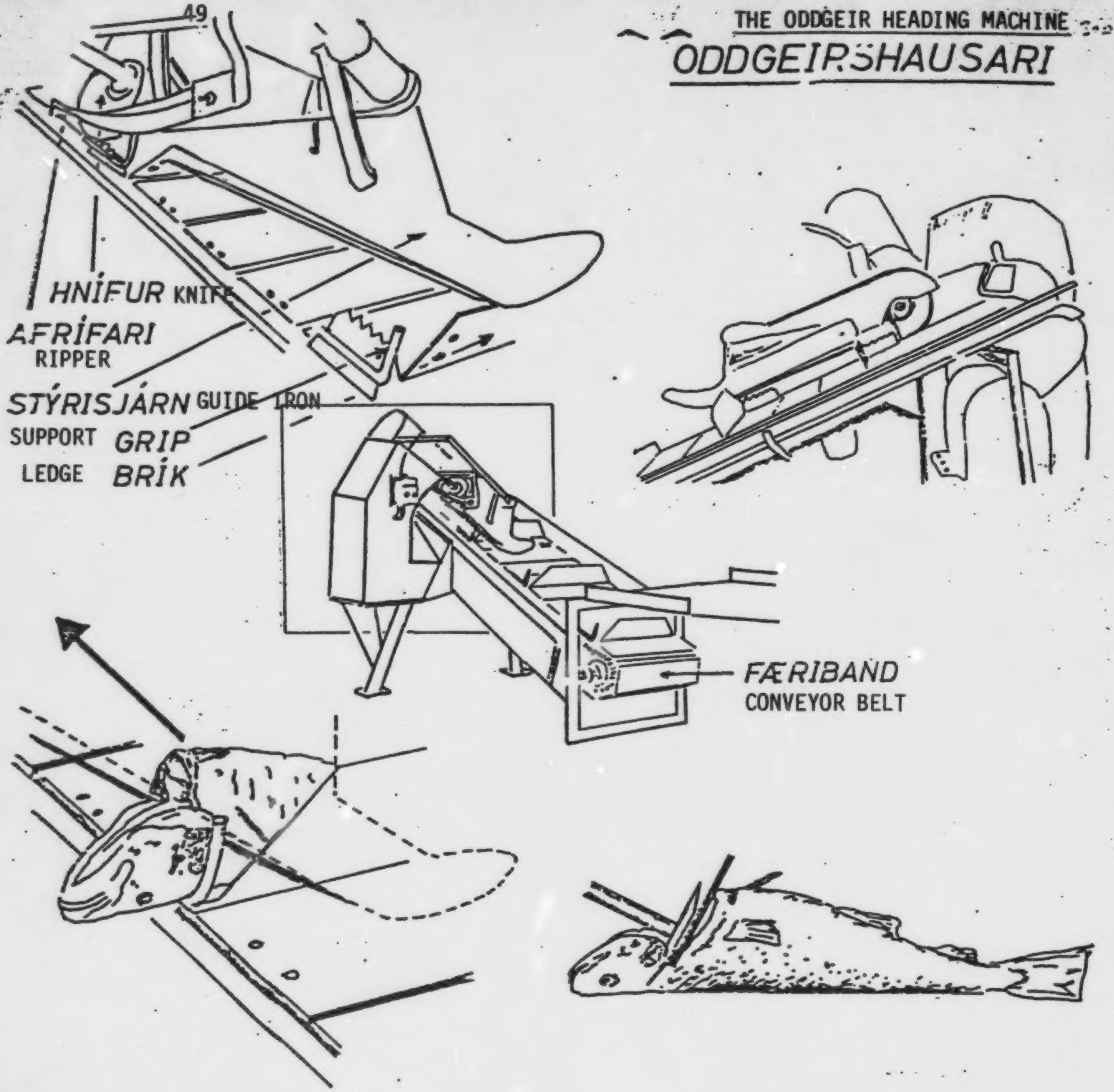
Splitting damage: In Table 6 we see that splitting damage in salted fish occurred in 3.5% to 6.4% of inspected samples. Table 9 shows that splitting damage was found in 2.4% to 32.4% of split fish inspected at ten salted fish processing plants. The most common defect by far was air bladder spots caused by too shallow back stripping cuts, cf. Table 9, but this does not cause a serious defect in fully processed salted fish. If, on the other hand, part of a flap has been cut away we have a more serious defect which will downgrade the fish into 2nd or 3rd quality product. This defect does not always occur, but is becoming somewhat more common.

General: Some general conclusions can be drawn from the data presented in Table 9 and elsewhere in this manual. Autolysis chiefly occurs in netted fish, and only in certain cases. Line-caught fish are free of this problem. The rate of breaks is low in iced netted fish, or lower than in un-iced fish.

In processing plants H and I, fish was being processed which had been stored for one day on board the fishing vessel after bleeding, while in the J plant the fish had remained on board the fishing vessel for 48 hours. In the latter instance, autolysis was far more frequent and the incidence of breaks higher.

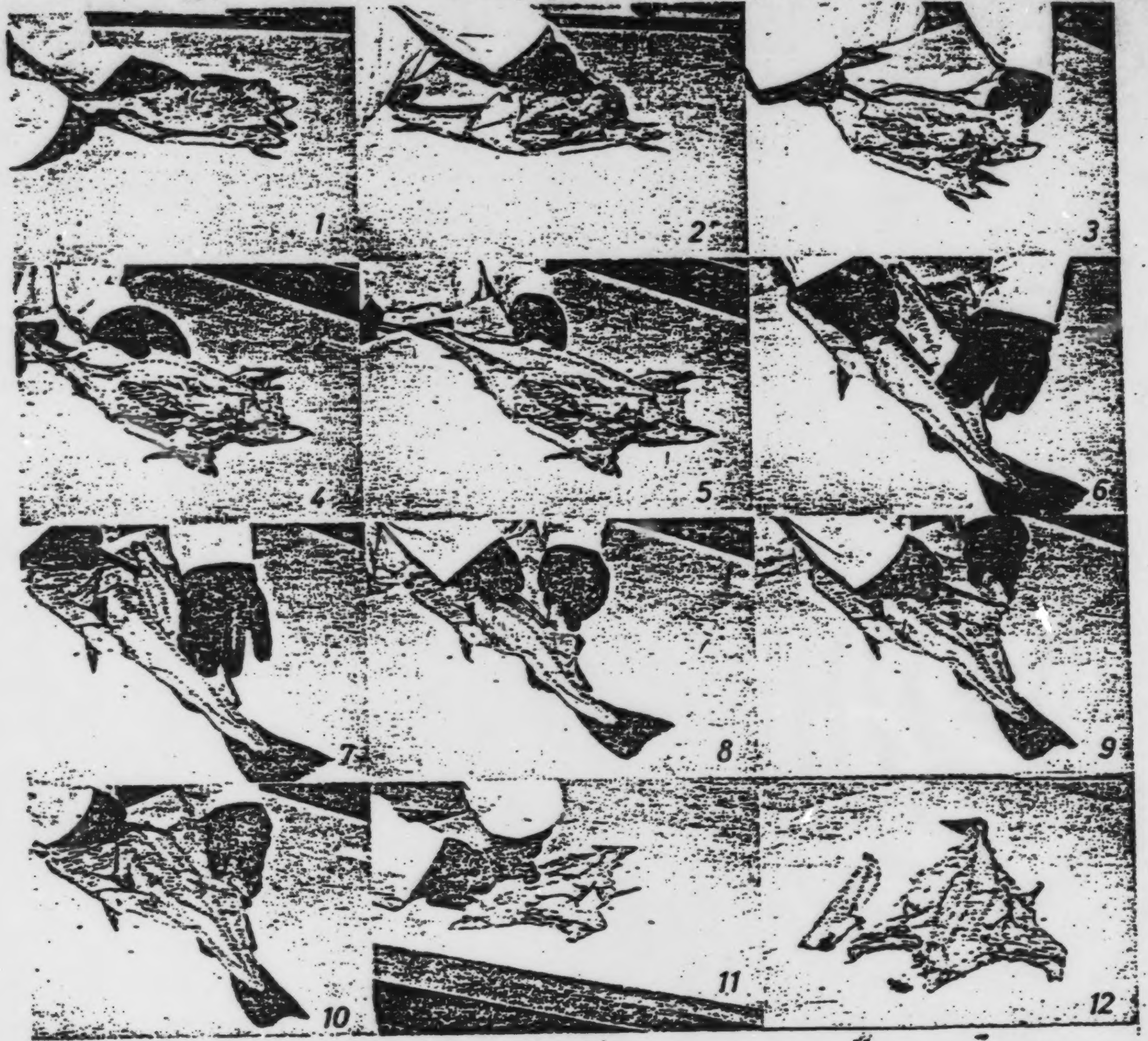
THE ODDGEIR HEADING MACHINE

ODDGEIRSHAUSARI

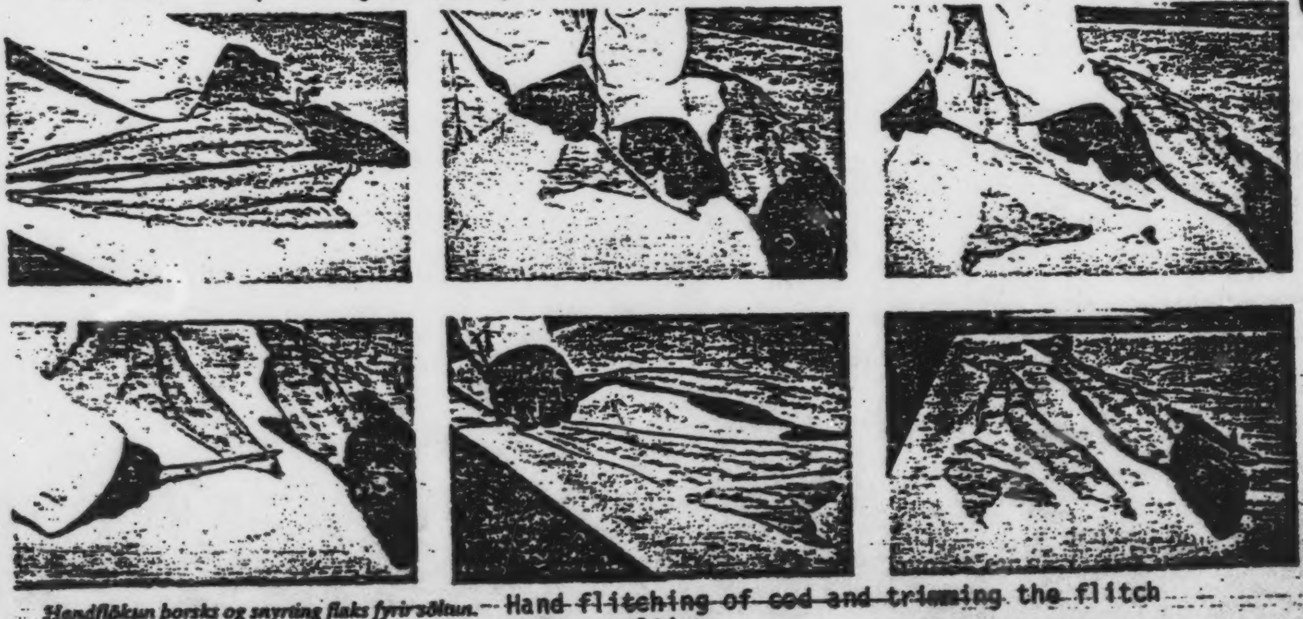

HNÍFUR KNIFE
AFRÍFARI
RIPPER
STÝRISJÁRN GUIDE IRON
SUPPORT
LEDGE
GRIP
BRÍK
FÆRIBAND
CONVEYOR BELT

filleting

Flatning og flökun þorsks Splitting and flitching of cod.



Handflatning þorsks. Splitting of cod by hand.



Handflökun þorsks og snyrting flaks fyrir söltun. Hand flitching of cod and trimming the flitch before salting.

Table 9: Examples of defects in split cod arising during heading, gutting and splitting; percentages.

	Salted fish processing plant:	A	B	C	D	E	F	G	H	I	J
	Number of fish examined:	87	128	132	112	126	130	137	137	127	123
	Method of catching:	line	line	trawl	trawl	net	net	net	net	net	net
	Landed: bled / gutted:	gutted	gutted	gutted	gutted	gutted	bled	bled	bled	bled	bled
	Landed: iced / not iced:	iced	iced	iced	iced	iced	no ice	no ice	no ice	no ice	no ice
	Landed: pens / boxes:	pens	pens	boxes	boxes	boxes	pens	pens	pens	pens	pens
	Heading machine make:	Oddg.	Oddg.	Oddg.	B414	B414	B.IS001	B414	Oddg.	Oddg.	Oddg.
Raw material defects	1. Autodigestion of flaps	0	0	0	0	0	0	0	5.1	5.7	15.8
	2. Breaks in fish flesh	3.4	16.4	9.1	8.9	4.8	10.0	5.1	19.1	3.8	13.2
Heading defects	3. Gill fragments remaining	1.1	0	1.5	1.8	0.8	2.3	0	2.9	3.8	4.4
	4. Parts of head bone remaining, "crumbs"	6.9	0.8	17.4	10.7	0	0	9.5	0.7	1.0	1.8
	5. Flap/s loose from neck	5.7	1.6	3.0	9.8	18.3	0	1.5	0	0	0
Processing defects	6. Collarboneextends from flap	0	0	0	4.5	4.0	1.5	5.1	2.9	7.6	0.9
	7, Heart remains in neck	0	0.8	0.8	0	1.6	3.8	2.2	9.6	10.5	0
	8. Liver fragments adhering	2.3	3.1	5.3	0	2.4	6.2	2.2	0.7	7.6	2.6
	9. Stomach or part thereof remaining	0	4.7	0	0.9	0	0	0	0	0	0
	10. Gut fragments remaining	2.3	9.4	2.3	6.3	3.2	0	2.2	0	1.0	0
	11. Roe fragments remaining	0	0	0.8	5.5	0.8	0.8	0	1.5	0	0
	12. Milt fragments remaining	2.2	0	0.8	0	2.4	2.3	0.7	3.7	8.6	0
	13. Anal appendix remaining	6.9	0.8	9.8	2.7	11.9	2.3	8.8	0.7	6.7	6.1
Splitting defects	14. Splitting hole	1.1	1.6	0	0	0	0	0	0	0	0
	15. Parts of one flap cut out	2.3	0	0	2.7	0	1.5	2.2	5.9	0	1.8
	16. Air bladder spots, one side	16.1	10.9	3.8	0	2.4	3.1	2.2	7.4	15.2	18.4
	17. Air bladder spots, both sides	3.4	3.9	0.9	0.9	0	14.6	0.7	3.3	1.0	12.2
	Fish with no or insignificant defects	56.3	54.7	53.0	55.4	57.1	61.5	69.3	43.8	35.7	30.7
	Number of workers trimming with knife/brush	none	none	none	none	1,knife	2,knife	2.knife	2,knife	2,knife	2,brush

Table 10: Some of the most common defects arising from processing and splitting.

	Defect	Explanation	Remedy
During heading	Collarbone exposed.	Bleeding or heading cut too close to collarbone.	Improve heading/bleeding procedure, i.e. cut less close.
	Head bone remains in fish body.	Incorrect placing in heading machine.	Place correctly in heading machine.
	Neck truncated.	Incorrect heading. Part of neck has been cut away.	Correct heading procedure to prevent cutting into neck.
	Flap loose from neck.	Raw material unfresh and/or mishandled. Incorrect heading. May also be caused by rough handling during gutting.	
During gutting	Anal fin segment in coalfish.	Belly cut on wrong, i.e. left, side.	Belly cut on coalfish must be on right side.
	Flap segment.	Gutting cut not in middle of belly.	Belly cut must be in the centre.
	Right and left flaps remain joined.	Gutting cut in belly not long enough.	Cut must extend to the anal opening on all species except coalfish, where cut must reach the middle of the anal fin.
	Cut extends into flesh near anal opening.	Cut extends beyond anal opening. On coalfish, cut extends beyond midpoint of anal fin.	Cut must end at correct point on belly.
In splitting machine.	Piece cut out of flap.	Badly placed in trough, flap lies underneath fish belly.	Place fish correctly with flaps widely separated before edge of trough.
	Fissures increasing in fish with or without prior breaks.	Knives poorly sharpened.	Sharpen knives, meanwhile split fish by hand.
	Tail not fully opened to tail fin.	Splitting knife blunt or guide cam incorrectly set.	Sharpen splitting knife; readjust cam.
	Flesh segment cut away, leaving splitting hole.	Splitting cut too shallow. Machine not adjusted for small fish. Splitting knife too low.	Readjust splitting knife and machine for small fish.
	Splitting cut too shallow.	Splitting knife too low.	Raise the splitting knife.
	Fish cut totally in half.	Splitting knife does not drop down in splitting machine.	Requires adjustment of gauge rod or gauge device for tail clip.

Table 10 (continued)

	Defect	Explanation	Remedy
In the splitting machine	Blood spots occurring where back has been severed.	Splitting cut too long due to incorrect setting of splitting knife control cam.	Readjust splitting knife control cam for the type of fish being split.
	Blood spots occurring where back has been severed.	Bone stripping knife control cam incorrectly set. Back section being cut away is too short.	Readjust control cam.
	Back section being cut away is too long.	Control cam setting incorrect.	Readjust control cam.
	Air bladder spots on split fish.	Stripping cut is too shallow; too little flesh accompanies backbone. Occurs chiefly in larger fish.	Bone stripping knife guides must be lowered.
	Bone stripping cut too deep in split fish.	Backbone is removed with too much flesh.	Bone stripping knife guides must be raised.
	Black membrane of unequal size in flaps.	Bone stripping knife guides set an unequal height.	Readjust and equalize setting of guides.
	Entire backbone has been removed from fish.	The pawl on the roller lever does not release, causing pressure to be maintain along entire length of fish against the bone stripping knives.	Machine failure which must be corrected. Pawl may have to be replaced.
	Fissures increase after completed splitting.	Fish catapults off conveyor and breaks behind machine.	Better receiving arrangements behind machine. Covers are required over conveyor.

4.7. Washing

Washing procedures vary very widely. Often the fish is rinsed upon receiving or at landing on its way to heading. Such washing removes fragments of viscera, blood from the bleeding procedure, and mucous adhering loosely to the fish. Most common is to wash the fish again after splitting in a washing machine comprising a washing tub which the fish drops into off the splitting machine, and out of which the fish is pulled up on a conveyor belt.

The purpose of washing is to remove blood, liver particles, visceral fragments, bacteria and microorganisms emanating from the digestive tract, as well as other debris and mucus. The raw material varies and the catch may be landed either gutted or ungutted. One therefore cannot recommend a universal washing procedure for all circumstances, since requirements are determined by several factors. Extensive washing is questionable and risky in some instances. Washing should therefore be adequate, not excessive; this applies in particular to washing after splitting. If fish remain in the washing water after splitting, the water will dissolve significant amounts of albumen out of the exposed muscle tissue, thereby increasing the likelihood of breaks and fissures. Flavour will probably also be adversely affected.

General recommendations.

1. It is preferable to wash bled and gutted fish before heading and splitting in order not to necessitate washing of all fish after the splitting procedure, but only of those fish showing obvious contamination. Ungutted fish should also be washed before splitting.
2. Best is to wash ungutted fish after heading and gutting. Gutted and headed fish retain the entire peritoneal membrane. Loose blood, digestive enzymes, gut bacteria, liver particles and other visceral remains should preferably be removed before the fish is split and the muscle exposed. After splitting it is also necessary to wash any fish showing blood spots from the splitting procedure. Neck blood must usually be cut away and the fish rinsed. Water exposure after splitting must be minimized.
3. Fish which show general contamination after splitting and require complete washing should remain in the water the shortest time possible.

Risks.

1. If digestive enzymes and gut bacteria have not been washed out of the peritoneum, the likelihood of breaks and fissures increases, as does the incidence of autodigestion and deterioration during storage.
2. If blood is allowed to enter the brine tub or fish-house, various types of blood defects will arise; cf. the defect grading scale.
3. Liver particles which have not been washed off cause liver spots; this constitutes a serious defect.
4. If the fish remains in the washing water after splitting, the risk of breaks and fissures increases. Flavour quality is probably also affected and yield is significantly reduced.

Washing tubs

In recent years it has become increasingly common to wash fish in specially made washing tubs. These tubs are equipped with running water and the fish are brought out of them on a rising conveyor. In other respects the equipment varies in size and type, adapted to prevailing conditions of use. The tub is sometimes fitted with a net or grid at the bottom which moves up and down, gradually bringing the fish to the conveyor which transports them out of the tub. This process also activates the fish in the water. Other tubs use water jets mounted around its walls to move the fish.

Generally speaking, washing occurs both before and after splitting. It is recommended that all motion around the fish in the water be kept very gentle and never excessive in order to reduce the risk of breaks and fissures. It is also important that the fish does not remain too long in the water. The risk of fish bunching together on the conveyor must be prevented, as well as any tendency for the fish to vault off the ledge of the conveyor.

It is advisable to construct tubs which permit opening from below in order to clean the bottom and let out fish particles and other debris.

Occasionally two washing tubs are mounted in sequence; the fish go from the first into the second. The possible advantages of this arrangement are uncertain while, on the other hand, risks are increased.

In some fish processing plants a washing tub is employed after gutting and before the fish is split. This arrangement is unquestionably favourable, in particular if it is possible to eliminate washing after splitting whenever the raw material so permits; see above.

4.8. Pre-salting - general comments

The main purpose of pre-salting is to remove as much water as possible from the fish flesh and achieve the highest possible salt uptake in the shortest possible time. The objective is to check the destructive effect of decomposition and bacterial proliferation by means of the salt-induced drying.

The initial salt uptake is very rapid. The rate slows as the salt content of the fish increases and the moisture level drops. As salt uptake progresses, a corresponding amount of water leaves the fish. Usually the water content will have fallen from about 80% to 65-70% after three days under normal conditions. At this time the salt content will have reached the 10-12% range (see figure 2), which constitutes two-thirds of the ultimate salt uptake in the fish. Considerable water will yet leave the fish, during which process the salt content increases further to reach the level resulting from the increased uptake. When the water has reached a low point of 50-60%, it becomes very difficult to induce additional salt to enter the fish.

Chemical and denaturation changes start promptly when salt enters the fish. Water from the fish starts to dissolve some of the salt outside the fish, creating saturated salt brine. This salt brine in turn draws more water out of the fish flesh while, at the same time, salt penetrates into the flesh where it forms salt brine. Initially this brine is weak, but as increasing water is drawn out of the fish the strength of the internal salt brine increases and eventually becomes fully saturated (proportion of salt and water in the flesh approximately 1:3), or reaches equilibrium with the salt brine outside the fish flesh. When this point is reached, the salt uptake and salt-induced drying process is complete; it will have taken about 2-3 weeks at low temperature.

While there is considerable salt uptake during the pre-salting period, the fish loses a great deal of weight during this period because of the drying effect of salting. As an example, split cod with a water content of about 80% loses about 20% of its weight in brine during 3-4 days, and about 30% during one week's dry salting in the fish-house.

It is very hard to achieve all the four objectives of salting (see 4.1.1.) in a single salting procedure, especially if the fish is to be sold and exported as soft-cured. Re-salting after pre-salting ensures more even salt distribution and salt-induced drying, and re-stacking ensures in addition that the soft-cured fish will stand up to all the rough treatment and handling it encounters during exportation. Concurrently the fish has time to reach fully cured state, i.e. the ultimate chemical and denaturation changes have taken place in the fish flesh alongside the main salt uptake and water displacement during pre- and re-salting.

It is not possible closely to define the parameters of pre-salting, re-salting, 1st and 2nd re-stacking except in terms of production objectives. If the objective is to minimize production costs, and a few weeks make no difference, you may obviously reduce the frequency of re-stacking and let the fish remain a little longer in each stage. If, on the other hand, the fish must be made ready for exposrt with minimum delay, it is advisable to shorten the duration of each stage and increase the frequency of re-stacking.

The suitable temperature range is 5^{o}-10^{o}C. No generally optimal temperature can be specified, since this is influenced by the characteristics of the raw material, available production time and other relevant production objectives. The fish cures more rapidly at higher temperature, but will also become darker during certain procedures. Raising the temperature therefore increases costs as well as the defect rate. The degree and duration of pressing during re-stacking must also be considered separately for different products. Low-grade fish with breaks requires more and longer pressing than firm high-quality fish. It also makes a difference whether the fish is to be exported in rigid cardboard boxes, or in unprotected canvas packages.

Comparison between brine anddry pre-salting

Compared to older traditional dry salting methods, brine salting affects both costs and defects and has taken over almost completely in the last 10 years.

The main cost factors are:

a) Significant process rationalization has been achieved in the arrangements designed for this procedure, making pre-salting a comparatively easy task. - Previously, pre-salting was one of the most arduous procedures in the manufacturing process. Today it is always carried out on premises that are both bright and warm.

b) Less salt is generally used in this type of pre-salting than in dry salting. Salt penetration also becomes easier and more satisfactory.

c) Better use of premises is achieved by stacking the brine troughs three high, instead of dry-salting in stacks of up to 1 m in height.

d) Improved salted fish yields are obtained from good, live-bled fish when brine salted, compared to traditional fish-house salting and based on the same moisture level in the product, because of reduced loss of albumen from drainage.

fillets

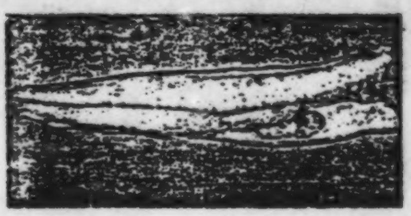
Various flitches for salting etc.

58.

Ýmis flök til söltunar o.fl.

Flökun löngu og snyrting flaks.

Flitched ling and trimming of the flitch.

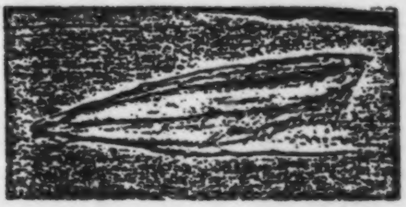


Lönguflak til söltunar.

Flitch of ling for salting.

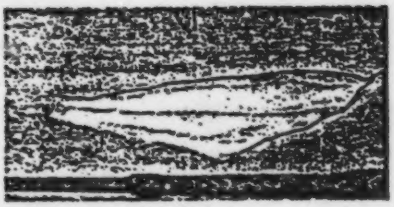
Flökun ufsa og snyrting flaks.

Flitched coal-fish and trimming of the flitch.



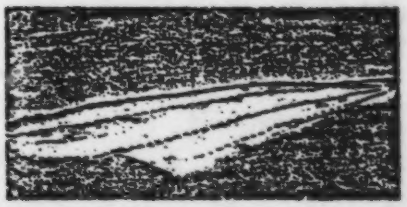
Snyrt ufsaflak til söltunar.

Trimmed flitch of ling for salting.



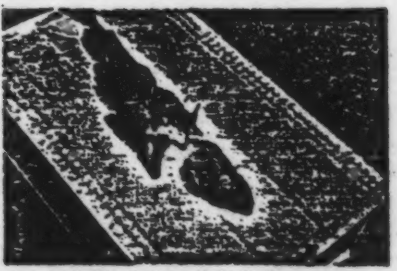
Snyrt þorskflak til söltunar.

Trimmed flitch of cod for salting.



Snyrt þorskflak, þunnildi er að mestu fjarlægt.

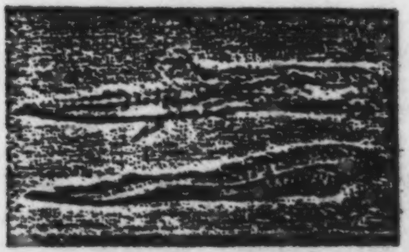
Trimmed flitch of cod, most of the flap has been removed.



Æskileg hausun í hausunarvél. Hnakkasotan er löng og vel löguð.

Desirable heading in heading machine.

Point of the neck is long and well formed.



Flatningargalli. Allur hryggurinn er tekinn úr fiskinum.

Splitting defect. The entire backbone has been removed from the fish.

e) Brine salting generally arrests bacterial activity more rapidly than dry presalting.

Defects:

a) Brine salting requires more accurate salt distribution and stacking of the fish compared to dry immersion salting because of the much smaller quantity of salt used. Uneven salt distribution can cause mis-salting spots.

b) Brine salting requires more careful differentiation between live-bled and dead-bled fish since fish with bleeding defects easily colour unblemished fish in the brine tub with a yellowish or light brown colour. More or better washing of fish being processed is therefore required before brine salting.

c) Fish with broken flesh, i.e. fish which breaks up during splitting, has a greater tendency to show breaks and fissures in the fully processed product if the initial salting stage was brine salting. In addition the salted fish yield shows little or no improvement in respect of netted cod bled dead, when brine salting is compared to dry fish-house salting.

d) In crowded or difficult working conditions, or at sea, brine salting is less suitable than dry salting. Working conditions must be designed for brine salting.

4.8.1. Brine salting

Brief description: Brine salting is the initial salting stage, also called presalting, and constitutes a curing procedure for fish in its own juice. The fish (split, flitches, flaps, etc.) are placed in a receptacle or tub, and salt is spread over each layer in sufficient quantity to ensure that a quantity of undissolved salt is always present in spite of the increasing production of brine. The salt draws out water gradually from the fish, resulting in the formation of saturated salt brine (24-26% salt). Concurrently the salt enters into the fish, gradually effecting those changes in the albumen along with biochemical processes which result in the characteristic taste, consistency and aroma of salted fish. How long the fish should remain in the brine is a matter of opinion. Usually the fish is left to cure for 3-4 days in the brine; however, if the raw material is of good quality there is no reason why it should not remain for longer. After 3-4 days at usual brine temperature (8^{0}-10^{0}C) the fish will have absorbed approximately 2/3 of the salt it will ultimately have taken up when fully cured. At the same time the fish will have lost somewhat over half the water it must lose before it is ready for export as soft-cured fish.

Icelandic "brine salting" of cod and related species differs from Canadian and Norwegian brine salting in that in Iceland it is carried out in preparation of exportation as soft-cured fish, while in the other countries brine salting is used in the manufacture of fully-cured (dried) salted fish. There the fish remains in brine for 4-5 days before drying if it is lightly salted, and for 2-4 weeks if it is fully salted. When out of the brine the fish is washed and stacked high (with small amounts of salt between layers) to flatten the fish better, making it easier to dry subsequently. The main difference between brine salting and dry salting is that in the former instance, the fish floats in saturated salt brine, i.e. in its own juice, while dry salting causes the brine to flow out of the fish flesh as soon as it is formed. The brine treatment period is usually equal to half the duration of the 1st stage of dry salting; consequently it is necessary to salt the fish well during brine treatment to achieve sufficient pre-salting, i.e. about 2/3 of the salt uptake and half of the water loss, with the remainder taking place in the re-salting process.

The brine tub is a receptacle wherein split fish can be easily arranged in layers, and easily removed after brine treatment has been completed. The height and width of tubs must take into account that workers bend over to the bottom of the tub to arrange or take out the fish during brine treatment. Usually tubs are 80-90 cm high, about 1 m wide, and from 1 m to 1½ m long. Cubic content ranges between 600-1000 litres. A very common size is 850 litres. The tub should permit salting of about 1 ton of cod, gutted with head (approx. 700 kg when split). Tubs are both manufactured in Iceland and imported. They are always completely water-tight (a precondition) and made from materials which can withstand the corrosive effect of salt brine and do not dissolve into the brine or damage the fish. Most tubs are made of plastic-coated steel (galvanized), synthetic materials (various plastics) or aluminium. It should be possible to overturn the tubs by means of the turning forks usually fitted to most lifts now used in salting plants.

Procedure:

After processing and washing, clean fish (split, flitched) are laid side by side with the skin-side down in the brine tub. Care should be taken to arrange the fish with a minimum of empty space between them. For this reason, tails should lie up against the side of the flaps, the fish thus lying in tight alignment. The succeeding layer is best arranged so that the thick neck sections fall in areas that are lower than the surroundings (flaps, sides of the tub). Salt is distributed as evenly as possible over each layer. It is very important that sufficient salt is spread over each layer (see section 4.7.). One must estimate how much salt the full brine tub will hold and then adjust the amount downward for each layer of fish. It is easy to determine how many layers are required to fill the tub to the brim. One should aim to have 20-40 kg of salt remaining undissolved when the fish have been removed from the brine at the end of treatment to ensure there is solid salt remaining between the fish. This means that up to 250 kg of salt is required per 700-800 kg of split fish, the approximate volume the usual plastic tub can hold.

Brine rapidly starts to flow over the fish (provided they have been well arranged) and after 1-2 days the fish are floating. The uppermost fish may then rise above the brine surface. To prevent this, additional salt must be spread over the top layer. Canadians deem it important to compress the fish to prevent them rising because of the risk of contamination by airborne bacteria, especially since fish remain longer in the brine in Canada. - As stated, it is a matter of opinion how long the fish should remain in the brine. The usual period is 3-4 days.

When brine treatment is complete, the fish are "torn" up one by one by hand and rinsed in the brine, especially if the brine contains loose debris, and then laid on a grid or other device for best drainage of brine from the flesh. The fish must now be promptly stacked, skin side up, and salted. - Another method used is to overturn the tub with a forklift. This requires a special grate or board to be secured on top of the tub to prevent the fish tumbling out when the tub is overturned. Tubs are then placed upside down on the floor. The grate is unfastened and the empty tub raised off the fish which have thus been turned skin side up. - In either case the fish are then left standing a short while until most of the brine has drained off. However, there are risks associated with leaving the fish to stand for long at this sensitive stage (see section 4.7.) and when this process is completed, the fish is ready for salting and stacking.

Risks: a) Lack of salt between fish will cause them to adhere, resulting in so-called mis-salting spots which may vary in colour from a watery grey to brownish. The colour probably depends somewhat on the nature of the raw material and on how much blood remains in the fish carcass.

b) If the fish shows bleeding damage (bled dead, bloody fissures, blood from processing), the brine will be contaminated. Fish remaining too long in such brine will become dark. It is therefore appropriate to remove fish with bleeding problems from the brine. It is also advisable to salt dead-bled fish separately, i.e. not together with unblemished raw material.

c) The brine tub must not get too warm. This must especially be watched with regard to the topmost tub when 3-4 tubs are stacked in a heated building with poor insulation. Desirable temperature is 5^{0}-10^{0}C.

d) Fish should not be allowed to stand for long unsalted and exposed after removal from the brine. The fish are then at a very sensitive stage and subject to darkening as well as yellowing. Best is to allow the brine barely to drain before salting and stacking.

e) If the fish has been left standing for long after brine drainage (a few hours), it will darken (become grey or yellow). Probably the properties of the raw material (blood content) will determine how sensitive the fish is at this stage.

4.8.2. Dry salting in stacks

The split fish are arranged side by side, skin side down, on a floor with adequate slope to prevent moisture on the floor from accumulating under the fish. Firstly, a thin layer of salt is spread on the floor. Salt is then distributed as evenly as possible over each layer so that the fish are well covered (immersion salting). Sometimes individual fish must be placed where hollows have formed, and salted separately. Each layer is arranged so that neck sections lean against flaps, and vice versa. One should calculate with 600-700 kg salt per 1000 kg of split fish. In this manner salting is continued until the stack is 100-120 cm high. Stacks should be 1 m wide so that a worker can reach around the entire stack when arranging the fish. Stacks are preferably placed close to each other. Under usual conditions the fish should remain 6-8 days in the stack. If fish remain longer than 6-8 days the likelihood of irreversible mis-salting spots increases. It is sensible to move the fish at appropriate intervals and provide fish at the top with more pressure by placing them at the bottom of the stack upon re-salting.

Risks: a) Insufficient salt between layers will cause the fish to stick together in spots, thus creating defects which do not disappear on re-salting (mis-salting spots). This applies especially to neck sections, since they are convex and often retain little salt during distribution.

b) If there is insufficient salt at the bottom of the stack, most of it will be carried away with the brine and into the fish. Fish in that position lose water because of pressure without sufficient salt uptake. Such fish will have impaired uptake capacity in the re-salting stack even if sufficient salt is available.

c) Neck sections and flap corners may emerge from the stacks unsalted and deteriorated (storage damage, yellow colouring). The Germans often distribute fine-grained salt around the extremes of the stack.

d) Empty spaces within the stack are growing grounds for bacterial activity which may damage individual fish along their sides.

4.8.3. Salt and its importance

The characteristics of salt vary from one type to another. Usually, salt is divided into three categories, i.e. sea salt, ground salt and industrial salt. Within each category there are many varieties or classes. As an example, Icelandic Reykjanes salt is an industrial salt harvested from marine soil.

Sea salt is most frequently used in Iceland for the curing of salted fish. Some ground salt is used. Icelandic industrial salt is still in the experimental stage. In 1981 Iceland imported some 75,500 tons of salt, most of it sea salt from Spain and Tunisia. Our annual purchases of ground salt amount to 1000-3000 tons.

Sea salt is produced mainly in countries with hot and dry climates. The sea is vaporized in pools. The salt (NaCl) is crystallized at the bottom and the dug up. Most sea salt is washed after harvesting from the pool before grinding. However, an exception is Ibiza salt which has enjoyed some use here in recent years. Salt from Tunisia is also washed.

Ground salt is mined from earth strata in various countries in Western Europe and elsewhere. Our purchases have so far mainly been from Holland and West Germany. Ground salt is old sea salt which has crystallized at some time in the distant past. Some of it is very clean compared to unwashed sea salt. The seas contain many salts other than NaCl.

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Table 11: Composition of the most common salt types used in Iceland.

Substance	Ground salt	Sea salts Torrevieja	Sea salts Tunisia	Sea salts Ibiza
	%	%	%	%
Water	0.40-0.50	2.5-1.8	2.3-1.3	2.6-3.1
NaCl	98.0-99.0	97.3-97.7	97.1-97.8	96.1-94.5
$CaSO_4$	0.53-0.72	0.15-0.32	0.17-0.30	0.82-1.58
$MgSO_4$	0.04-0.17	0.00-0.10	0.10-0.30	0.16-0.38
$MgCl_2$	0.00-0.42	0.00-0.12	0.10-0.30	0.16-0.48
Na_2SO_4	0.04-0.49	-	-	-
Water insoluble	0.10-0.40	0.10	0.10	0.10
Iron	4-30mg/kg	12-25mg/kg	10-15mg/kg	13-17mg/kg
Copper	-	0.01	0.01	0.01

Table 12: Grain size of certain salts.

Grain diameter (measured in aperture gauge)	Ground salt	Sea salts Torrevieja	Sea salts Tunisia	Sea salts Ibiza
	%	%	%	%
Greater than 2.83 mm	28	32	35	42
2.057-2.83 mm	14	33	26	22
1.68-2.057 mm	9	12	13	12
1.41-1.68 mm	7	7	11	9
0.84-1.41 mm	15	11	13	11
0.5-0.84 mm	10	4	2	3
Smaller than 0.5 mm	17	1	0.2	0.6

As shown in Table 11, ground salt is the purest and contains 98-99% NaCl. Ibiza salt contains the most $CaSO_4$. The calcium content is of considerable importance, as shall be discussed later. Insoluble matter and impurities are not necessarily connected to the origin of the salt, but frequently result from handling, storage and transportation.

Reykjanes salt is very pure in its original condition and the calcium and magnesium salts may be mixed as required.

Grain size also plays an important role. Representative grain sizes for the salt types discussed are shown in Table 12.

Contamination and impurities. Various contaminants or impurities may be present in the salt. Previously the most serious contaminant was copper which caused so-called copper yellowing which created violent objections in many countries. Oil in the salt is also serious and the salt must be discarded if it has an oily odour. Frequently other types of impurities, such as rust etc., contaminate the salt, especially during transportation, but these impurities are generally easy to spot.

Microorganisms are also present in salt, particularly in sea salt which may contain hundreds of thousands of red halophilic bacteria per gram. Red bacteria belong to the so-called salt-loving (halophilic) bacteria and can be found in numerous varities in sea salt which differs from one source to another, and from one lot to another.

Ground salt generally contains few bacteria, but may be affected by fungi and moulds, etc. Industrial salt is usually the cleanest in terms of microorganisms.

Importance of composition and grain size.

Ideally the salt should be pure NaCl and contain no additional matter, such as calcium salt and $CaSO_4$, $CaCl_2$ or magnesium salt. Calcium salt, and to some extent magnesium salt, bind and consolidate the fish flesh at and just below the surface, making it lighter or whiter than it would otherwise be. It is advisable that the calcium content not exceed 0.2%, which corresponds to 0.5% $CaCl_2$ or 0.7% $CaSO_4$. If the $CaSO_4$ content is high (above 1%), a white crust will form on the surface of the flesh during brine salting and must be washed away if significant. This very rarely occurs when pre-salting is carried out in stacks instead of brine tubs. Excess calcium also seals the surface, thus impairing salt uptake which prevents the desirable "curing" or "denaturation" from taking place. From the reasons mentioned it will be clear that the calcium level must be kept within the stipulated levels; the maximum level also depends on the properties of the raw material. It is advisable to use the more calcium-rich salts for raw material which is loose or has a tendency to break and would result in salted fish with breaks or fissures, as well as when the salted fish is likely to become blotchy or dark.

The magnesium content must not be too high or the product will acquire a bitter taste. Copper must not exceed 0.1 mg/kg due to the risk of the salted fish yellowing. This is caused by chemical processes, triggered by the copper, which result in an increase in certain lipid compounds. If a cargo or lot of salt is found to contain an average of 0.1 mg/kg copper, even in isolated samples, use of the salt may still be risky due to the possibly unequal distribution of the copper. In such cases several samples must be analyzed as a precaution against possible damage.

Grain size is also important. Ideally it should vary so that the salt contains both small and large grains. Small grains dissolve easily. They rapidly form brine and salting thus commences quickly. Large grains dissolve slowly and form layers of coarse salt in between the fish. These layers help prevent the fish from adhering. The reason is that large grains remain in place and do not drain away with the brine, thus maintaining the fish at a certain distance from each other. Too fine-grained salt forms a hard crust on the fish surface because the salting effect is too rapid; this prevents continuing salt uptake, especially at low temperature and in stacks.

Experiments have shown that the grain size distribution found in salt products detailed in Table 12 is generally satisfactory. How desirable a different distribution pattern might be cannot be determined from the abovementioned experiments and the precise information on raw material and pertaining curing procedures available. Finegrained salt should be used for packaging (herring salt).

If the salt is damp, brine is produced more rapidly than when the salt is dry, but distribution of the salt is hampered. To ensure more even and satisfactory distribution one must increase the salt quantities if the salt is damp or very coarse-grained.

Requirements under the Codex Alimentarius for salt used in the salting of cod species (Gadidae).

1. Salt intended for the production of salted fish (stockfish) must comply with the standards of the Codex Alimentarius for table salt.
2. Composition.

Dry matter:	not less than 96%
Calcium:	maximum 0.3% Cu (0.7% $CaCl_2$ or 1% $CaSO_4$)

Magnesium: maximum 0.1% Mg (0.5% $MgSO_4$ or 0.4% $MgCl_2$)

3. Contaminants.

Copper: maximum 0.1 mg/kg Cu

Iron: maximum 10 mg/kg Fe

4.9. Re-salting and re-stacking: general considerations

The purpose of re-salting and re-stacking is to complete the curing of the fish, ie. the salt uptake and drying, for the purpose of achieving those features and characteristics which pre-salting alone cannot accomplish. How frequently re-salting and re-stacking is carried out depends on circumstances. The aim with this procedure is to reach a moisture level of 52% or less and a minimum salt level of 19-20% when the production objective is "fully processed" salted fish. By re-salting and re-stacking, the following curing effects are achieved which pre-salting alone cannot ensure:

1. Adequate drying and salt uptake,
2. Evenness of "curing", i.e. in respect of water and salt content and thickness,
3. Increased firmness.

Evenness of curing from fish to fish, as well as between different sections of individual fish, is achieved by:

a) re-stacking, which makes it possible to equalize the pressure treatment required to obtain the desired dryness and firmness. Fish located at the top of the stack and are subject to little pressure, are placed at the bottom upon re-stacking, and so forth.

b) re-salting, which makes it possible to improve the degree of salt uptake in those fish, or isolated spots, which have not absorbed sufficient salt during pre-salting, or in the 1st salting stage after brine salting. Thick neck sections may have been placed together with insufficient salt in between. Moreover, too little salt may have been used in certain areas of the stack. Re-salting is therefore an important safety measure from the salting standpoint.

c) repeated stacking, which increases the evenness of thickness. The thickest sections or areas are usually flattened the most and therefore become firmer. Firmness, as previously stated, is one of the production objectives.

In addition to a, b, and c, moving the fish at intervals probably has a positive effect both on water drainage and salt uptake, i.e. the curing process is accelerated. During re-stacking, each individual fish is taken up and exposed to a certain amount of movement which, while increasing the rate of breaks, also creates minute fissures or ducts through the firm surface, thus accelerating the curing.

It is difficult to differentiate specifically between re-salting and re-stacking in terms of purpose. However, the main objective of re-salting is to optimize the ultimate salt uptake and drying, while re-stacking is intended to achieve evenness and complete curing. Little salt is used between fish layers during re-stacking.

In terms of firmness,the fish must be quite rigid before packaging in order to withstand the rough handling it will encounter during transportation, and in order not to lose excessive weight before reaching the consumer. There is considerable variation between "good" and "poor" salted fish in this respect. Good quality fish (1st or 2nd grade) usually emerges from salting much firmer than poorer quality fish and does not require the extended period of very even pressure which poorer quality fish must be subjected to during re-stacking. The type of packaging is also important. Unprotected fish in canvas packages must be more rigid and better pressed to stand up to handling in transit to destination, than if the same fish had been packaged in boxes or loose on trays.

4.9.1. Re-salting (1st re-salting) and re-stacking after brine treatment

Three methods are used for transferring fish from the brine to the stacks. The first procedure involves taking up the fish by hand from the brine tub and arranging them on trays, skinside up, so that brine will drain off along the skin and not through the fish flesh. The trays are then moved to the fish-house where the fish are dry salted and stacked about 1 metre high. The second alternative involves moving the tub to the fish-house where the fish is dry salted as it is taken out of the brine. The third procedure requires the brine tub to be covered by a board whereupon it is overturned by a forklift equipped with a 180° rotating arm and laid on the floor, i.e. the board with tub on top. The board is then released from the tub which is lifted off. This leaves well stacked fish on the board, lying skinside up. Dry salting and stacking is then carried out off the board as described above. The last-mentioned procedure is not considered advisable if the brine is very contaminated, or if the salt used for brine salting was contaminated or rich in $CaSO_4$.

At this re-salting stage, about 600-700 kg of salt is used per 1000 kg of brine-salted fish, which corresponds to some 1,300 kg of split, unsalted cod. Of most importance is that the salt is distributed evenly over all the fish which must be evenly arranged in stacks which are as level as possible. In this manner any irregularities arising in individual fish during brine salting will be smoothed out. In the stack the fish continue to take up salt and lose moisture, i.e. the main salting process (the pre-salting) is divided into two stages, the first being the brine treatment (approx. 2/3) and the second (approx. 1/3) consisting of dry salting in stacks. This reduces the risk of mis-salting blemishes and localized storage damage.

During this re-salting, or 1st fish-house salting, the fish remain stacked for 10-14 days (preferably at a temperature of 5-10°C). They are then removed from the salt and re-stacked in stacks (1.8 m high) or on trays with much less salt between layers, i.e. using one-third to one-half the quantity per layer compared to the 1st fish-house salting. When fish is pre-graded it is useful to stack 3rd and 4th grade product in 1.8 metre stacks, and 1st and 2nd grade product in stacks 0.8-1.0 metre high. Salt falling off the fish during this procedure is often used, if clean, for brine salting and during re-stacking. By using new salt for re-salting, fairly good salt is obtained for brine salting and re-salting whereafter it is discarded, since salt which is old or has been used repeatedly must not be employed in the processing. New salt is obviously the ideal at every stage.

The fish remain re-stacked until processing is completed and the fish ready for packaging. By re-stacking the fish under refrigeration before being fully processed, it is possible considerably to delay its readiness for packaging and exportation, or maintain it well pending disposal.

Whether re-stacking should be carried out once or twice is a matter of opinion which, as stated before, depends on the original condition of the raw material, the production objectives and the timing of packaging for export. Generally very little salt is used for the second re-stacking and sometimes the surface of the fish is simply sprayed with salt. The need is usually greater to re-stack 3rd and 4th grade product than 1st or 1nd grade, taking breaks and fissures into account.

During re-salting special attention must be paid to the following:

1. Good or new salt must be used - preferably with the appropriate content of calcium compounds (cf. 4.8.3.).
2. The fish must be stacked and arranged as evenly as possible.
3. Irregularities in the fish must be smoothed out during the stacking process.
4. Salt must cover the entire fish, i.e. the fish must be immersed in salt.
5. Fish removed from the brine must be salted without excessive delay.

Main risks during re-salting:

a) The use of insufficient salt will result in mis-salting spots or areas.
b) Creases in the fish or severe skin irregularities will cause defects which can only be partially resolved by re-stacking.
c) Contaminated salt causes colouring defects and increases the likelihood of other problems occurring if the right circumstances arise.
Examples are mould and reddening.
d) If the fish are allowed to remain too long exposed and un-salted after the brine has drained off, the fish may darken (cf. 4.8.1.).

Main risks during re-stacking:

Generally speaking, the major risk of storage damage has passed at this stage. However, the following circumstances can arise:

a) If the temperature is too high, the fish may yellow or darken. Ideally the temperature should be in the range of 5-10°C.
c) There may be yellowing along the edges of stacks (neck portions). Germans spray fine-grained salt over fish sections protruding from the stack.
c) If the fish have not been evenly arranged in the stack, irregularities or rumples may arise which cannot later be remedied.

4.10. Storage

4.10.1. Storage in the fish-house

Fully processed fresh fish can be stored for several months or even years under refrigeration (2-4°C) without suffering significant chemical changes. The fish is usually stored in regular stacks (re-stacked to about 120 cm) or on trays at high relative humidity and a temperature of 2-4°C. The fish will unavoidably lose some weight, mostly during the initial 4-6 weeks of storage, despite having been fully processed when placed in storage. There is little subsequent weight change.

Over 4-5°, the fish will lose increasing amounts of weight, the higher the temperature. Fish must be refrigerated immediately the desired production objectives have been reached (or mainly reached). 3rd or 4th grade product should not be refrigerated until fully processed, but "lightly processed" or "medium processed" fish must be refrigerated as soon as the appropriate curing stage is reached.

Risks:

a) If the temperature exceeds 4-5°, the fish will lose excessive weight which results in reduced yield (weight).

b) Higher temperature (8° and over) also increases the risk of damage by reddening. If the temperature reaches 12°, it can be taken for granted that reddening is merely a matter of time.

c) Higher storage temperature generally causes darkening of the surface colour (becoming yellow or light brown), relative to refrigerated storage.

d) Too low temperature and large surface areas (fish dispersed, low stacks, trays) causes unnecessary weight loss from evaporation.

4.10.1. Storage of packaged salted fish

If packaged salted fish must be stored for a considerable period, refrigeration is essential (4-5°). This is to prevent both weight loss and the risk of reddening. Experiments have shown that packaged salted fish (canvas packed) with a moisture content of about 52% loses approx. 1% per week at 4-5°C, when stacked six packages high. At 16-18°C the weight loss is 2-3% per week when stacked to the same height. Weight loss increases with the height of the stacks. Obviously fully processed salted fish will thus lose over 5% in two weeks at 16-18°C. Less humid fish will of course store more readily. Storage at 25° causes both reddening and decomposition within 2-3 weeks.

Figure 4 shows the pattern of weight loss in a parcel of salted fish (52 kg, canvas packed) under different conditions. For comparative purposes, the weight loss pattern for 52 kg of salted fish in the fish-house is also shown.

4.11. Packaging and grading

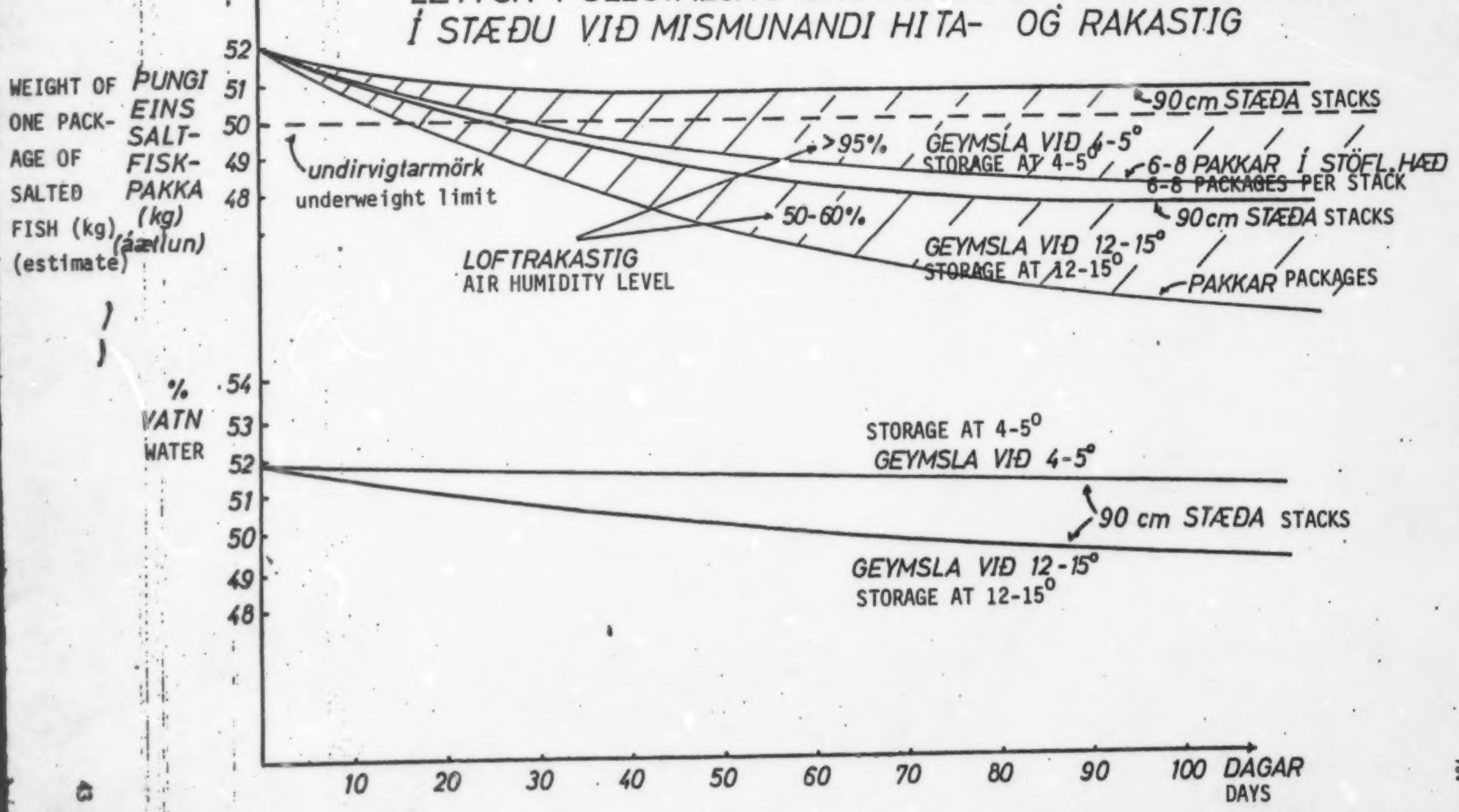
As discussed in section 2.3, salted products are exported in four types of packages, trays, cardboard cartons and canvas packages.

Mynd 4.

Figure 4.

WEIGHT LOSS IN FULLY PROCESSED SALTED FISH AFTER PACKAGING OR IN THE FISH-HOUSE AT VARIOUS TEMPERATURE AND MOISTURE LEVELS

LÉTTUN FULLSTAÐINS SALTFISKS EFTIR PÖKKUN EÐA Í STÆÐU VIÐ MISMUNANDI HITA- OG RAKASTIG



Appraisal, which may only be carried out by authorized appraisers, takes place in conjunction with packaging. Appraisers are authorized by the Ministry of Fisheries under recent legislation. Special public regulation apply to the grading of salted fish. The essence of these regulations is that salted fish being exported from Iceland must be appraised and quality graded before leaving the country in packaged form. This applies to all salted products. Exceptions are salted fish products processed on board the fishing vessel and which is exported in the fishing vessel without being landed in Iceland.

Authorized appraisers carry out their duties under supervision of the chief fish appraiser of the Fish Products Inspectorate. Appraisers are paid by the salted fish producers and are permanently employed by them.

The Fish Products Inspectorate has issued separate guidelines for salted fish appraisal which deal with desired appraisal conditions and necessary information relating to the actual appraisal regulations as well as to the marking of packages.

S.Í.F. issues guidelines concerning the marking of packages and the co-packaging requirements for various individual products. These guidelines also deal with the salt added to packaged products as well as the various packaging stamps required for various fish and package sizes. It is essential for all producers to have access to the most recent information from the sales association in the form of guidelines, circulars or by direct contact in cases where no written guidelines exist.

4.12. Drying of salted fish

Previously, most salted fish was dried before exportation from Iceland. Today, most salted fish is exported soft-cured. The drying of salted fish is intended to improve its capacity for storage and decrease the cost of transportation; besides, dried salted fish is a widely commercialized traditional product.

Before drying, soft-cured salted fish must be washed and re-salted. Loose blood and visceral remains are cleaned out of the salted fish by the washing. Flaps are also trimmed at the front.

Mostly the membrane is removed from the flaps; this is done by hand. Generally the fish are washed in machines equipped with revolving cylinder brushes under intensive water flow.

On completed washing, the salted fish are arranged in stacks. Salt is then sprayed over each layer in sufficient quantity to prevent the fish adhering. Suitable stack height is 1.5 metres while the fish are being pressed and flattened. The salted fish are ready for drying after maximum one week. Main objectives of re-stacking include:

- Fish at the top will be at the bottom after re-stacking and will be better pressed.
- Air circulates around the fish during the re-stacking procedure.
- Most breaks and folds are smoothed out.
- Loose and undissolved salt is removed.

Thereafter the fish are dried on thin drying frames, usually 80x80 cm^2 or 100x100 cm^2 in cross section and width. These frames consist of a wooden rim over which a wire or plastic grid is strung. Frames are arranged in storage boxes or storage containers which run on castors.

The frames are stacked in tiers 7-9 cm apart in the storage boxes once the salted fish have been laid out on the grids. Frames are stacked about 20 high. The fish are arranged so that the skin faces the grid. It is important to arrange the fish so that they do not cover each other, thus delaying the drying process and causing uneven drying of the fish flesh.

Traditionally the drying of salted fish is divided into 2-3 periods with re-stacking in between. The reason for this staggered drying is to prevent the surface from drying out without giving water inside the fish sufficient time to reach the surface. The intent of re-stacking is thus to ensure even distribution of water within the fish flesh, thus accelerating drying and preventing parching of the fish surface which would impede drying. It is important that the fish surface be adequately moist to facilitate the drying process. Salt within the fish flesh binds water and significantly retards water drainage to the surface.

Air flow in the drying chamber is set at 1-1½ m/sec. Air flow is maintained between frames, the air being blown across the stacks or storage boxes. There are several reasons for selecting this air velocity, including the following: Air flow in excess of 3 m/sec forms a crust on the fish surface; water flow from the interior of the fish to the surface is so slow that an air flow of 1 m/sec can remove the water; and a higher flow rate is detrimental for operating purposes. When blowers are selected for the drying of salted fish, a rough approximation or "rule of thumb" can be used which equates the fan power in Kw with the capacity of the drying chamber in tons.

The most appropriate temperature is 18-25°C and the relative humidity in the drying chamber should be in the 30-65% range. If the temperature in the drying chamber exceeds 27°C, there is a risk that the fish may cook. Relative humidity below 30% will cause the fish to shrivel up, while a relative humidity above 65% significantly prolongs the drying process. Operating conditions for each drying stage should be:

1st stage: Temperature 18°C, relative humidity 65%, moisture in fish flesh is reduced from 52% to 46%.
2nd stage: Temperature 21°C, relative humidity 55%, moisture in fish flesh is reduced from 46% to 40%.
3rd stage: Temperature 25°C, relative humidity 45%, moisture in fish flesh is reduced from 40% to 35%.

Drying chambers for salted fish must be equipped with automatic controls which always maintain the desired temperature and humidity inside the chamber, independently of the progressing drying or the outside weather. Excessive air flow, low temperature or dry air at the beginning of drying will create a crust on the fish surface and seal all moisture within the fish.

It is necessary to grade the fish by size before drying since it is inappropriate to dry large and small fish together, the drying time being dependent on fish size.

Dried salted fish is mainly exported in four drying stages:

1. 7/8 dry fish with 45% moisture content
2. Portugal dry fish with 40% moisture content
3. Hard-dried fish with 35% moisture content
4. Extra-dry fish with 30% moisture content

The number of drying stages is selected according to the stage at which the fish will be exported. Each drying stage takes 24-48 hours. Between stages, the fish remains in the fish-house for about 7 days, stacked to a height of 1.4 metres. The drying time for Portugal dry fish is about 10 days using customary salted fish dryers.

Conveyor belt dryers exist which accelerate the drying of salted fish, drying the fish in a single operation. In these dryers the fish is pressed between two rollers to achieve even water distribution in the fish flesh. Conveyor belt driers make it possible to obtain Portugal dry salted fish in 48-72 hours, thus shortening the drying time by one week.

Provisions must be made around salted fish dryers for adequate working space for re-stacking. It is not excessive to dimension such space to be three times that of the dryer itself.

Storage space for dried salted fish must preferably be cold and independent of exterior conditions. Most appropriate storage conditions are at 2-5°C with a relative air humidity of about 70%. Humidity levels above 80% cause water uptake by the salted fish, while air humidity below 55% causes evaporation and continuing weight loss. The fish are stacked skinside down, except to topmost layer which should be turned skinside up.

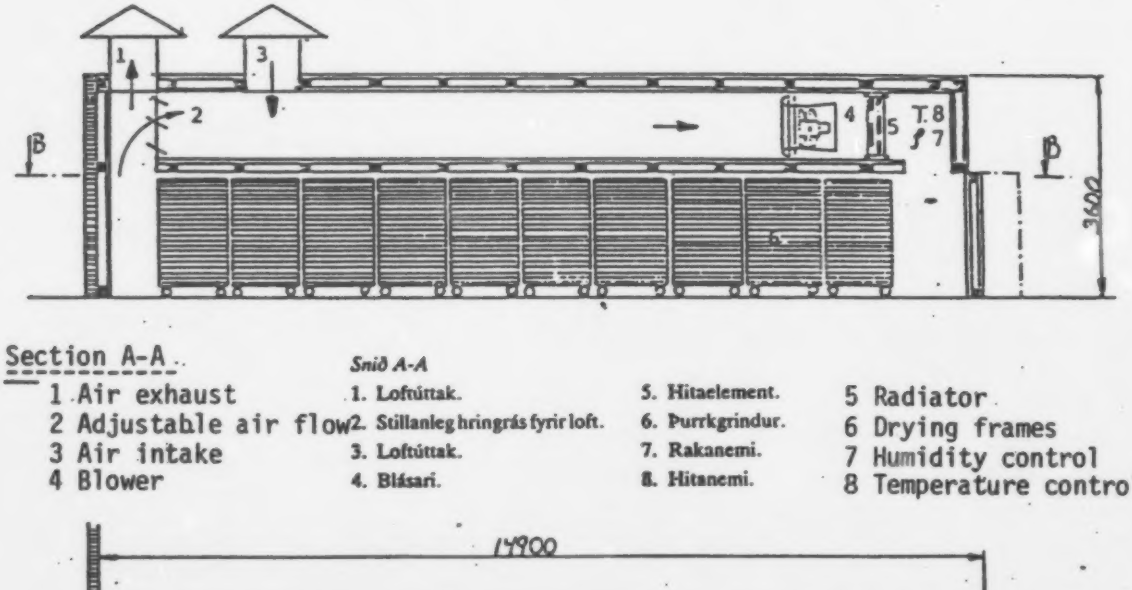
The yield of salted fish after drying depends mainly on the final extent of drying and is shown in Table 13.

Table 13: Yield of salted fish (cod) upon drying:

Degree of curing:	Water content:	Yield at processing*:	after drying:
	%	%	%
Salted fish	52	41	100
7/8 dry fish	45	35	87
Portugal dry	40	32	80
Hard-dried	35	30	74
Extra-dry	30	28	69

* Yield upon processing compared to gutted fish with heads.

Figure 5: Drying chamber for salted fish.
Mynd 5. Þurrkklefi fyrir saltfisk.



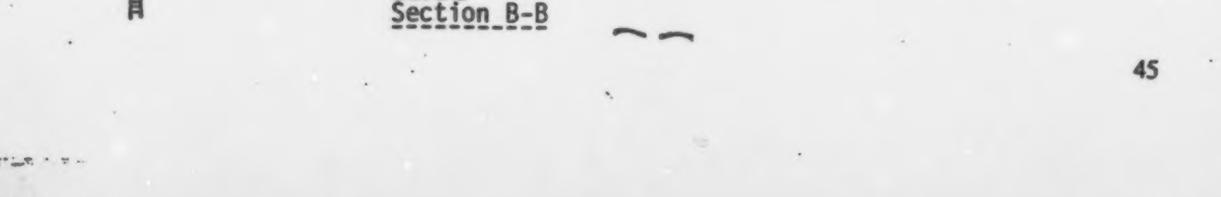
Section A-A

1 Air exhaust
2 Adjustable air flow
3 Air intake
4 Blower

Snið A-A

1. Loftúttak.
2. Stillanleg hringrás fyrir loft.
3. Loftúttak.
4. Blásari.
5. Hitaelement.
6. Þurrkgrindur.
7. Rakanemi.
8. Hitanemi.

5 Radiator
6 Drying frames
7 Humidity control
8 Temperature control



Snið B-B
Section B-B

Some key numbers in the salting of dried salted fish:
Load of salted fish on frame: 10.5 kg/m^2
Cubic weight of salted fish: 900 kg/m^3
Cubic weight of dried salted fish: 600-700 kg/m^3

5. Quality grading

Quality grading of salted fish has been carried out for many years in Iceland using traditional appraisal methods. These methods are described in guidelines from the State Fish Appraisal Authority and more recently the Fish Products Inspectorate. The traditional procedures have evolved over several decades and are adapted to existing working methods both in the curing of salted fish, and in the associated appraisals. On the other hand there have been significant changes in recent years in respect of working methods in salted fish curing plants. The properties of raw materials have also changed with changing trends on board the fishing vessels. It has now become necessary to define product characteristics much more accurately, both due to market demands and in order to provide proper correlation between production guidelines and defined product characteristics. Revised appraisal regulations are therefore required which define individual defects with the necessary precision. It is also essential to weight individual defects. Section 5.1 describes the proposed grading scale for salted fish, developed by the Fishing Industry Research Institute.

5.1. Quality grading by grading scale

General: The concept of the following grading scale for salted fish is based on a score system for apparent defects used e.g. in Sweden for the grading of potatoes, and recently introduced also in Iceland. It should be noted that a "total score" must be calculated for salted fish. This total score is then used to determine the quality grade.

Detailed description: The grading scale for salted fish is based on fairly precise information on all conceivable defects. Defects are weighted ¼, ½, 1, 2, 4 and 8, the score thus increasing the more serious the defect is. Using this score system an individual fish with a score of 1 falls into grade II under the traditional appraisal system. The correlation between traditional quality grades and the points system is as follows:

Points	Average points	Quality grade	
¼	(0-0.4)	I	(potentially "Premium")
½	(0.4-0.8)	I	
1	(0.8-1.5)	II	
2	(1.5-3.0)	III	
4	(3.0-6.0)	IV	
8	(6.0-8.0)	Waste (V)	

The points system permits compounding of defect scores. If a fish has two defects which both score 1 point, the total score is 2 and the corresponding quality grade 3.

Similarly it is possible to determine the points average for e.g. 10 fish selected as a representative sample. If individual total scores were e.g. ½, 1, 2, 1, 1, ½, 2, 1, 2, 1 the sum would be 12. This provides an average score of 1.2 which corresponds to quality grade 2.

The calculation can also be performed more simply by counting all defects in e.g. 100 fish, adding them together and dividing the result by the number of fish. This method cannot be used to calculate the total score for individual fish and gives no information on the spread between the inspected fish.

Based on inspection results it is thus possible to assign the fish a grade corresponding to a score of 1.2 (which is much closer to 2nd grade than 3rd grade), plus or minus 1 point. It then becomes necessary to determine how large a percentage of the fish fall within the appointed score limits ("scatter").

Some main considerations. Application of the proposed grading scale is based on the following main points:

1. It will provide processing plant workers with direct access to a comprehensible grading scale. Discussion or disagreement among workers concerning individual defects can be resolved according to logical principles.
2. Processing plant employees will be able to grade most salted fish into main categories. Regulations will be coordinated and worded so that they can be applied fairly accurately. Grading becomes de-mystified.
3. Appraisers will be able to work accurately to fixed regulations. Any material differences between them and the commercial stakeholders can be resolved on

the strength of the grading scale, or by amending it if the disagreement stems from inaccuracies in the scale.

Comments on the salted fish grading scale.

Weighting of defects is shown in roman numerals and mostly accords with appraisal results as presently obtained. A defect weighting of III thus indicates that the fish in question falls into the current 3rd grade. "U" indicates rejected fish.

A salted fish with a single defect would in all likelihood be assigned the same grade under the proposed scale as under the traditional appraisal method. If a salted fish has one major and one minor defect, the outcome will also be the same. If, on the other hand, a fish has two equivalent defects which, each on its own, would relegate the fish to 2nd grade, that fish would fall into 3rd grade under the new scale.

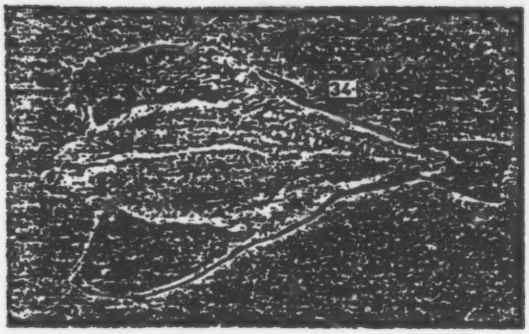
The grading scale is intended to remove any doubts about grading. Traditional grading methods and quality grade designations generate much dispute, especially since individual defects permitted within a certain grade are counted without there being any definition as to how many such defects are permitted. In addition, appraisers have attached their own valuations to the designations, and these are difficult to coordinate with the written facts or teach in the course.

5.1.1. Grading scale

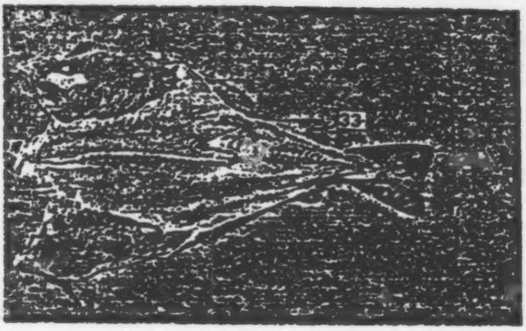
Defect weighting and defect points applicable under the quality grading scale as well as the main cause of problems.

81. Grading of salted fish

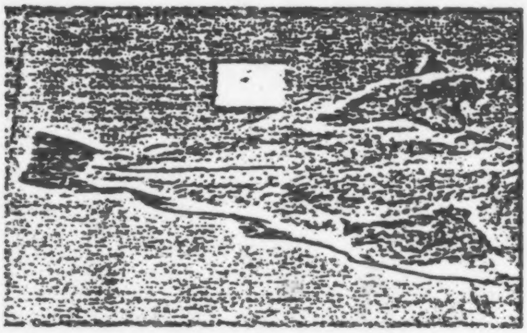
Flokkun saltfisks



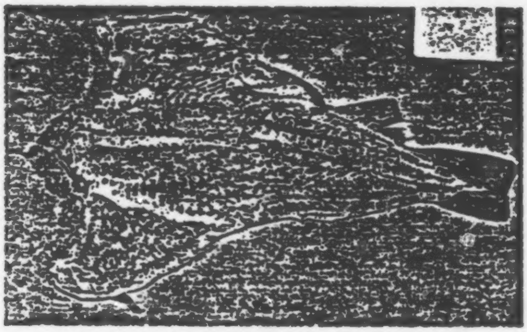
2. flokkur. Að mestu gallalaus fiskur.
2nd grade. Fish mainly unblemished.



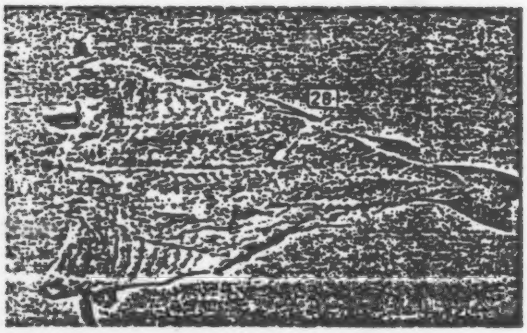
1. flokkur. Gallalaus fiskur.
1st grade. Fish unblemished.



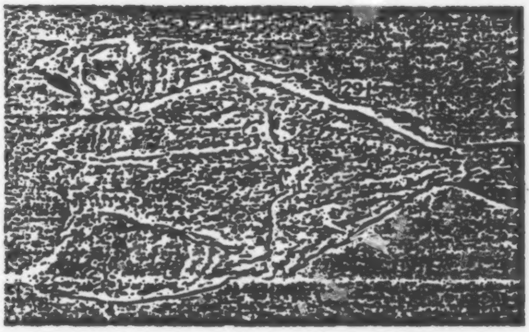
1. flokkur. Leifar af hnakkablóði.
1st grade. Traces of blood at neck.



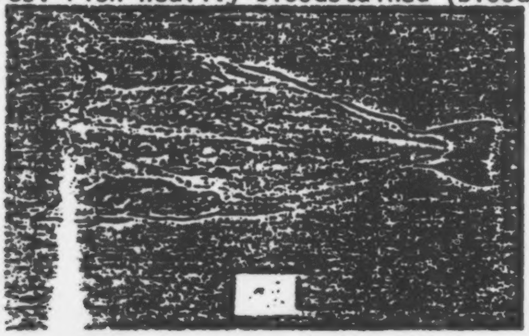
2. flokkur. Örlítið flamingargat.
2nd grade. Minimal splitting puncture.



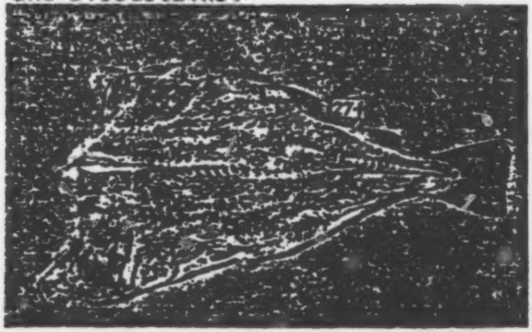
5. flokkur. Mikið los og miklar sprungur. Mikið blóðlitaður (blóðsprunginn) fiskur. 5th grade. Major breaks and fissures. Fish heavily bloodstained (bloody cracks).



5. flokkur. Þversprunginn fiskur með losi og blóðlitaður.
5th grade. Cross-cracked fish with breaks and bloodstains.



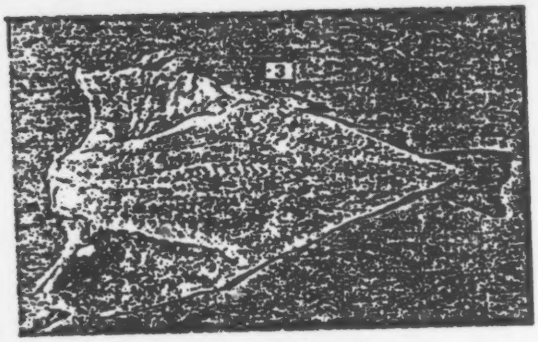
[illegible]. Mikið los og vansöltun. Stunginn hnakki.
4th grade. Major breaks and salting defects. Punctured neck.



4. flokkur. Sjálfsmelting í þunnildum. Los og blóðlitur.
4th grade. Autodigestion of flaps. Breaks and bloodstains.

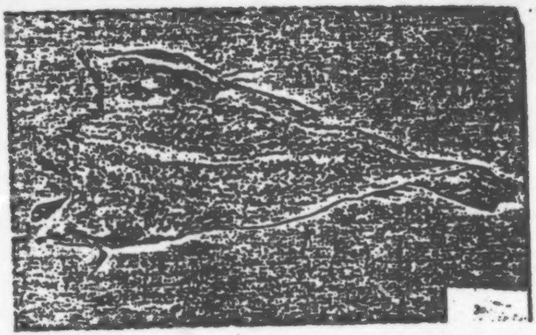
Grading of salted fish

Flokkun saltfisks

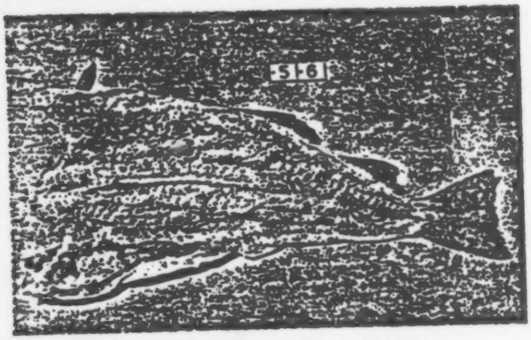


2. flokkur. Langsprunga með hnakkastykki.

2nd grade. Longitudinal crack along neck.

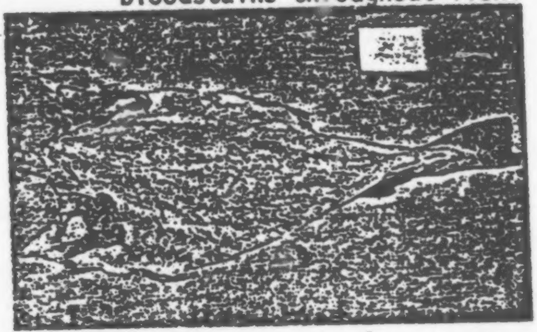


5. flokkur. Mikill blóðlitur í þunnildum, og allur fiskurinn er blóðlitaður. 5th grade. Major bloodstains on flaps, bloodstains throughout fish.

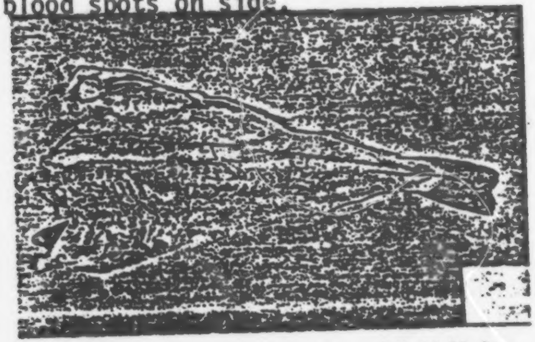


4. flokkur. Blóðlituð þunnildi og blóðblettir í stirtlu.

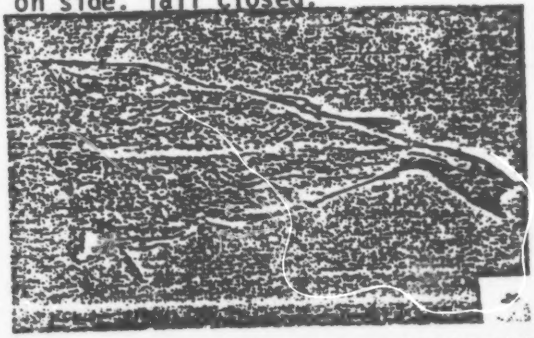
4th grade. Bloodstained flaps and blood spots on side.



4. flokkur. Blóðæðar í þunnildum og los stirtlu. Lokaður sporður. 4th grade. Veins in flaps and breaks on side. Tail closed.



3. flokkur. Geymslugalli og blóðlituð þunnildi. Moldarlitur og aðeins roðlitur. 3rd grade. Storage damage and bloodstained flap. Earth colour and some redness.

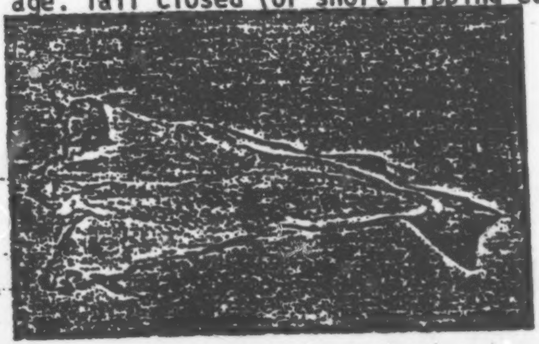


4. flokkur. Los og geymslulitur. Lokaður sporður (of stutt rist).

4th grade. Breaks and decolouration in storage. Tail closed (or short ripping cut).

4. flokkur. Los og blóðmar í hnakkakúlu. Moldarlitur.

4th grade. Breaks and bloody contusion of neck flesh. Earth colour.



4. flokkur. Stór lifrarblettur. (1. flokkur án lifrarbletts).

4th grade. Large liver spot. (1st grade if no liver spot).

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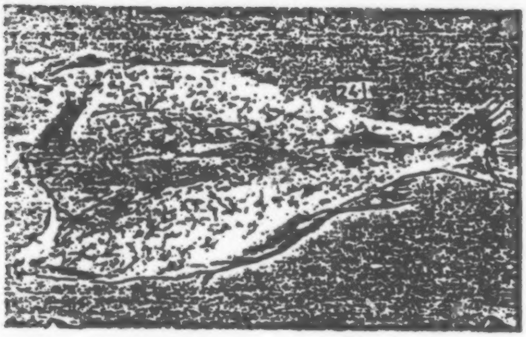
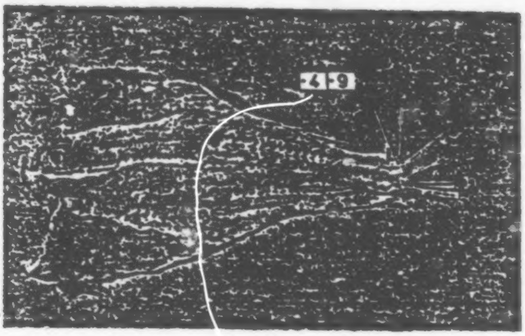
83. Grading of salted fish and individual defects

Flokkun saltfisks og einstakir gallar



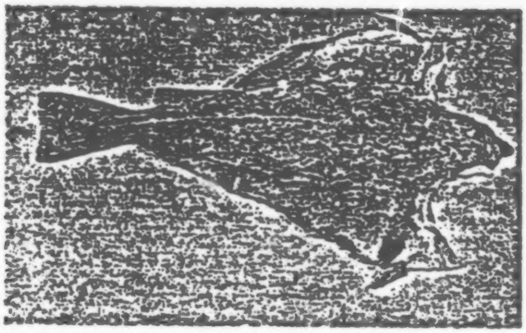
4. flokkur. Flóétinn fiskur.

4th grade. Flea-bitten fish.



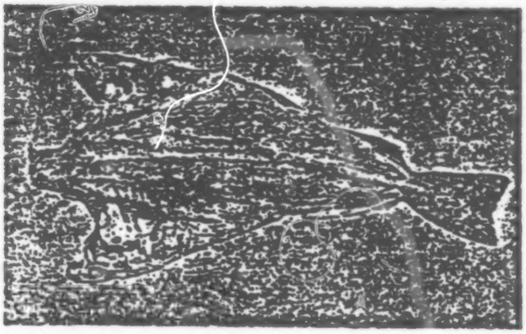
3. flokkur. Flóétinn sporður. Moldarlitur.

3rd grade. Flea-bitten tail. Earth colour.



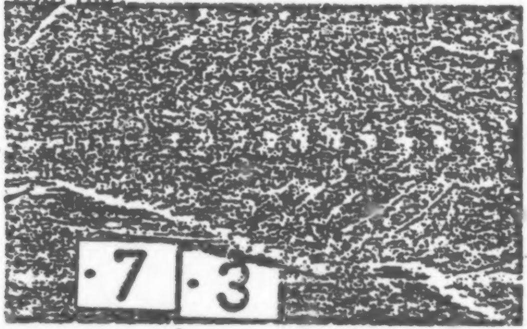
Þarafiskur. Þaraþyrsklingur.

Fish exposed to algae. Reddish coloured codling.



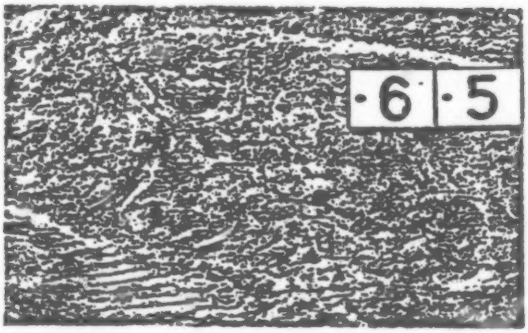
Ósaltaður fiskur með goggsár.

Unsalted fish with hook wound.



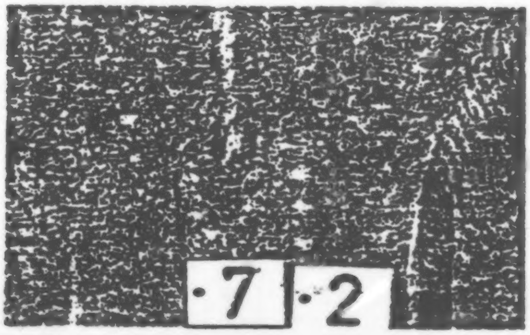
Blóð við hrygg. Blóðlitur.

Blood at back. Bloodstains.



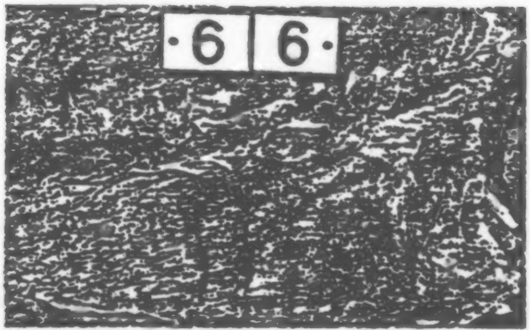
Los og blóðlitur.

Breaks and bloodstains.



Blóðlitaður fiskur og blóð við enda hryggjar.

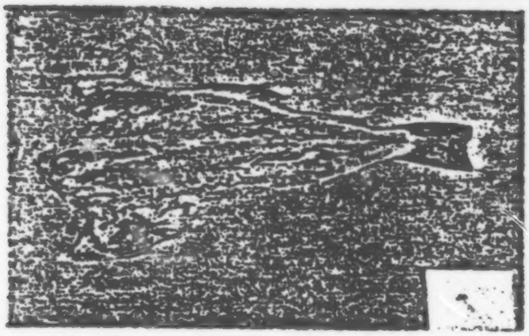
Bloodstained fish and blood at end of back.

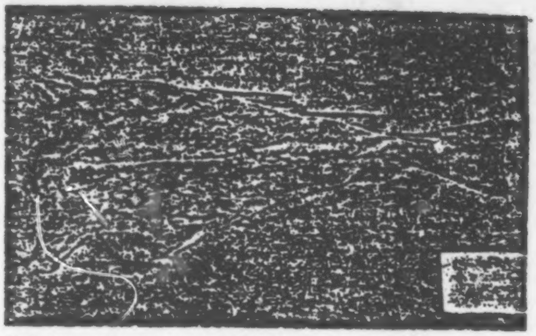


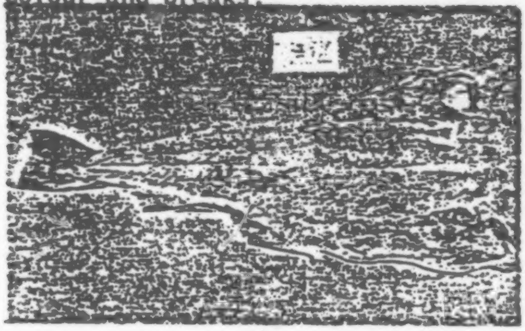
Blóðæðar í þunnildi.

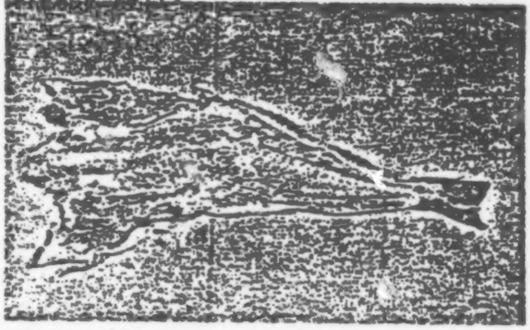
Veins in flap.

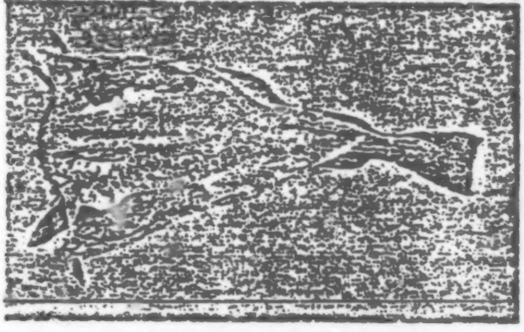
Grading of salted fish
Flokkun saltfisks

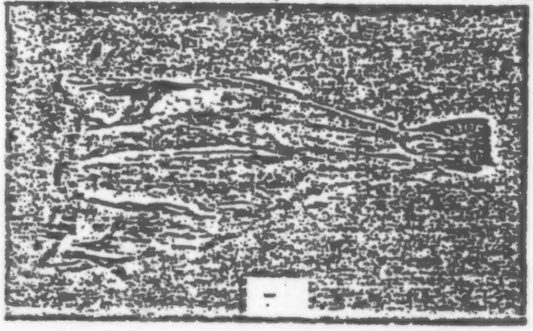

4. flokkur. Flatningargat. Hrálitur og los.
4th grade. Splitting puncture. Raw colour and breaks.

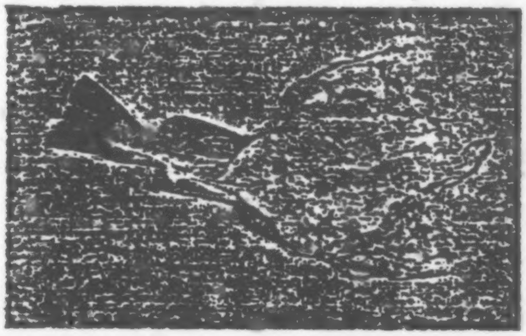

5. flokkur. Skorið úr þunnildi. Blóðblettir og lokaður sporður.
5th grade. Cutout in flap. Blood spots and closed tail.

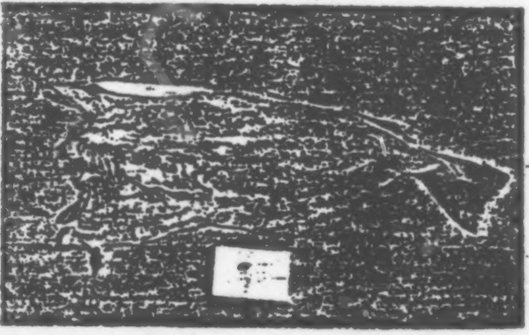

2. flokkur. Stunginn hnakki. Þunnildi aðeins laus frá hnakka. Blóðblettur við enda hryggjar. 2nd grade. Neck punctured. Flap barely loose from neck. Blood spots at end of t ..


3. flokkur. Lifrarblettur á hnakkakúlu og sundmagablettir. Leifar af hnakkablóði. Leiðinlegt lag. 3rd grade. Liver spots at and air bladder spots. Traces of neck blood. Condition poor.


4. flokkur. Klumbubein skorið af. Lokaður sporður og lifrarblettur á þunnildi. 4th grade. Collarbone cut off. Tail closed and liver spots on flap.


4. flokkur. Flatningargat og djúpristа. Marin síða. Sepi á þunnildi. 4th grade. Splitting puncture and deep cut. Bruised side. Appendix on flap.


4. flokkur. Lokaður sporður. "Labri" (smáfiskur).
4th grade. Closed tail. "Labri" (small fish).


5. flokkur. Los. Blakkur fiskur. (Moldarlitur og hrálitur).
5th grade. Breaks. Blackish fish. (Colour earthen and raw).

1. Defects in salted fish associated with the raw material		Defect weight	Defect points	Main cause of problem
1.1. Blood defects				
1.1.1. Veins visible in flaps				Fish was dead at bleeding.
a)	Dull veins visible in flaps.	II	1	Fish not drained.
b)	Prominent veins in one flap or some in both flaps. (Not visible everywhere in flesh of flaps).	III	2	
c)	Prominent veins generally visible in both flaps and in most areas of muscle tissue.	IV	4	
d)	Open (wide) veins, both flaps very dark and almost brownish-black in parts.	U (V)	8	
1.1.2. Earth (mud) colouring				Fish dead at bleeding. Congealed blood.
a)	Entire fish has light brown colour or shows dark streaks.	II	1	
b)	Fish has large brownish area (e.g. on flaps)	III	2	
1.1.3. Bleeding cracks and fissures				Fish exposed to excessive pressure on board fishing vessel, or left in heap before bleeding. Fish caught at great depth.
a)	Widespread bloodstains on one flap.	III	2	
b)	Both flaps darkened by blood.	IV	4	
c)	Large, dark, bloodstained (reddish) area covers most of both flaps or large area elsewhere	U (V)	8	
1.1.4. Contusions				Rough handling or injury before bleeding, e.g. on removal from net or caused by impact.
a)	Dark brown spot covers at least 25% of flap or contusion in flesh of neck or small contusion on side.	II	1	
b)	Contusion covers more than 25% of flap or entire neck area or side is bruised right through.	III	2	
c)	Contusion covers one flap entirely.	IV	4	
d)	Bloody contusion penetrates centre of fish.	U (V)	8	

1. Defects in salted fish associated with the raw material	Defect weight	Defect points	Main cause of problem
1.1.5. Pooled blood			Fish pierced by hook or otherwise punctured.
a) Minor blood spot (hematoma in flesh behind tail or between bones)	III	2	
b) Hematoma situated in neck or tail section. Damaged areas are joined. Puncture penetrates skin and spot can be seen from both sides.	IV	4	
1.1.6. Blood along back			Fish dead at bleeding or poorly drained.
Dark brown streak below backbone and extending out from spinal column. Spots often visible at end of backbone.	I	½	
1.2. Fish flaccid (May also arise from raw material storage or preparation).			
1.2.1. Breaks			1. Fish is flaccid for biological reasons when harvested live from the sea. 2. Fish exposed to rough treatment e.g. by prolonged trawling time or other pressure in fishing gear, during transit or storage on board fishing vessel or transport vehicle. 3. Fish flesh becomes progressively more tender with storage and increased temperature, whether at sea, on board fishing vessel, or in raw material storage at fish factory.
a) Prominent breaks, e.g. covering most of one flap, tail section or flesh around neck. Surface is flaccid and mottled with numerous small and irregular fissures.	IV	4	
b) Breaks and fissures extend across centre of fish ("cross-crack") or entire neck section has disintegrated and/or cracked. Breaks and fissures penetrate deep into fish and make it very sensitive to movement and rough handling.	U (V)	8	
1.2.2. Fissures			Caused by the samefactors and breaks.
a) Small cracks (superficial) in limited areas.	II	1	
b) Significant cracks (flap otherwise good and white). Fissures are fairly long and deep and mainly longitudinal	III	2	

1. Defects in salted fish associated with the raw material	Defect weight	Defect points	Main cause of problem
1.2.3. Autolysis (autodigestion)			Digestive juices (biochemical activity) have escaped from the digestive tract and digested the stomach cavity. Fish has been dead in the net or left too long before gutting in relation to conditions (heat, mishandling, time, gut contents).
a) Lightly visible autolysis in one flap (smaller than 6 cm^2, stamp-size)	III	2	
b) Early stage of autolysis in both flaps	IV	4	
c) Essential autodigestion damage in both flaps. Changes of consistency and texture have occurred in the flesh. Surface is rough and frothy and the flesh has receded (loss of substance). Damaged areas often reddish or brown.	U (V)	8	
1.3. Other defects originating from the raw material			
1.3.1. Worms			
Maximum two worms are permitted in individual fish; however not more than 15 worms are permitted per 50 kg. If more worms are present, they must be excised and the fish re-appraised.			
1.3.2. Flea-bitten fish			Shrimps have been able to draw blood and gnaw at live fish in the fishing gear (net).
a) Skin has become white (unnaturally fair) in spots but is not broken; fins are intact.	IV	4	
b) Fin bones are exposed or the skin punctured repeatedly. Fins are lacerated and the skin is generally more or less unnaturally light.	U (V)	8	
1.3.3. Loose collar-bone			Bleeding cut inexact. The knife has entered between the collar-bones and flaps or damaged the skin surrounding the bones.
a) Collar-bone (one or both) partially loose from flap.	II	1	
b) One collar-bone missing	III	2	
c) Both collar-bones missing	IV	4	
1.3.4. Emaciated fish			
Insubstantial and thin fish, conspicuously lean.	II(III)	1	

1. Defects in salted fish associated with the raw material	Defect weight	Defect points	Main cause of problem
1.3.5. Crab bites			
Small bloody punctures in flap or belly.	II	1	
1.3.6. Hook injuries			Inappropriate use of hook or pick.
a) Flap or tail punctured, blood in wound	II	1	
b) Hook wound and hematoma in one section of neck flesh	III	2	
c) Hook wounds and hematomas in both sections of neck flesh	IV	4	
1.4. Defects caused by storage of raw material			
1.4.1. Storage damage (yellow-brown colour).			Fish has been stored too long or at excessive temperature (blood colour often resulting).
a) Yellow or yellow-brown colour spread fairly evenly over up to 25% of fish surface.	II	1	
b) More than 25% of surface is yellow or yellow-brown	III	2	
c) Yellow or yellow-brown colour covers entire fish surface; in addition part of neck or tail section brownish	IV	4	
1.4.2. Frost damage			Fish has frozen after salting.
a) Raw colour ("dusky" colour) in less than 25% of tail section	II	1	
b) Raw colour covers 25-50% of tail section.	III	2	
c) Raw colour covers over 50% of tail or part of neck section.	IV	4	
d) Almost entire fish surface has raw colour (texture rough). Skin is pale.	U (V)	8	
2. Preparation damage			
2.1. Heading damage			
2.1.1. Punctured neck			Fish placed incorrectly in heading machine. Header cuts off to much of back and neck.
Neck has been severed almost in a straight line between the horns of the flaps.	II	1	

1. Defects in salted fish associated with the raw material	Defect weight	Defect points	Main cause of problem
2.1.2. "Crumbs" (headbone attached to trunk)			Header cuts incorrectly, i.e. too close to head.
Head bone fragments, posterior headbone section and/or edge of gills remain in fish.	I	¼	
2.2. Splitting damage			
2.2.1. Tail section closed			Tail clip on splitting machine grips outside or above tail fin, i.e. too far from end of tail. (Fish may also have been stacked un-slit without splitting damage).
a) Front of fish un-slit or not adequately opened down to tailfin. Fish mis-salted in closed area. Closed section extends 1-1½ hand's width from base of front side (root of tail).	II	1	
b) Closed section extends 2-2½ hand's widths from base of front side.	III	2	
c) Tail is closed to anal opening, or significant mis-salting shows when entire tail is opened.	U	8	
2.2.2. Cutouts in flaps			Fish incorrectly placed in splitting machine. Part of flap comes under spine and is cut away.
a) Less than 25% of one flap missing	II	1	
b) 25-50% of one flap, or <25% of both flaps missing.	III	2	
2.2.3. Split extends down to skin			Slit in tail section incorrect, cut extending down to or through the skin.
Slit 2-5 cm long down to skin in tail section. Skin visible through cut.	II	1	
2.2.4. Splitting puncture			Splitting machine not set for appropriate fish size and flesh firmness.
a) Split penetrates skin along front side down to tailfin (<5cm) or tail section is punctured at centre (<2cm).	III	2	
b) Splitting cut has penetrated centre of tail section (2-5 cm).	IV	4	
2.2.5. Deep cuts			Fish cut too deeply in front of spine in neck section, or not close enough to backbone at tail.
Fish is too thin along entire neck section or at centre of tail section.	I	½	
2.2.6. Spine split (shallow cut)			
Part of spine remains in neck section.	I	¼	Splitting machine incorrectly set.

1. Defects in salted fish associated with the raw material	Defect weight	Defect points	Main cause of problem
2.2.7. Spine too long (short) Backbone in tail section extends beyond (does not extend to) centre of anal fin. Blood spot (cross-crack) at end of spine.	I	½	Backbone severed at wrong point.
2.2.8. Air bladder fragments White spots (tough connective tissue) where flap and neck section join.	I	¼	Splitting machine incorrectly set.
2.3. Cleaning defects			
2.3.1. Liver spots			Liver fragments have remained in the fish during salting.
a) Fish has small reddish-brown (yellowish-brown) spot. Spot is easy to scrape off.	II	1	
b) Liver spot not larger than 10 cm^2 (large stamp)	III	2	
c) Liver spots larger than 10 cm^2 (3 cm edge). Spots cannot be scraped off without considerable damage.	IV	4	
2.3.2. Blood in neck section (from kidneys) Reddish-brown spots or "clots" are (often) found on both sides of neck flesh.	I	½	Splitting machine has left behind part of kidneys firmly attached to bone segments. During storage, clotted area has become reddish-brown.
2.3.3. Yellow mucus Surface of fish is yellow.	I	½	Mucus has not been properly washed off the fish. Other explanations exist.
2.3.4. Blood spots			Residual blood has congealed on fish surface, becoming hard and brown. Blood spots will form in the brine if fish poorly cleaned or drained of blood lie against other fish (mis-salting).
a) Isolated small blood spots visible.	I	½	
b) Fairly large or numerous blood spots visible	II	1	

1. Defects in salted fish associated with the raw material	Defect weight	Defect points	Main cause of problem
3. Salting and storage damage			
3.1. Mis-salting			Use or distribution of salt deficient in pre-salting stage. Fish badly placed during salting (flaps broken, fish closed).
a) Fish shows marks of mis-salting on tail section ("dusky" greyish-brown or "watery" grey colour).	III	2	
b) Marks of mis-salting on flaps and neck section, e.g. due to breaks arising in the flaps in the brine.	IV	4	
3.2. "Dusky" fish Fish is unnaturally dark-grey.	I	½	Insufficient calcium in the salt due to its original quality or repeated use. More frequent analyses required.
3.3. Crusts Pale crust loose on surface. May affect entire fish.	I	½	Salt contains too much calcium sulphate.
3.4. Tail closed (without mis-salting) Tail section of fish is closed. Fish has been fully or partially cut in usual procedure but cut is too shallow.	I	½	Fish placed closed in brine or stack, or closes up by itself (shallow cut).
3.5. Copper yellow Dark yellow colour fairly evenly spread throughout fish.	U	Non-gradable fish	Copper content (> 0.1 mg/kg) of salt is excessive.
3.6. Moulds Yellowish, brown or even black spots or specks which tend to cover an extended area.	U	Non-gradable fish	Temperature excessive on premises, combining with other conditions favourable to mould spores, including light.
3.7. Rot Reddish surface and soft texture. Rotten odour often present.	U	Non-gradable fish	Most probable reasons are use of moist salt or curing at excessive temperature ($> 8^{o}$C). Rot is often associated with the direct or indirect effect of sunlight.

1. Defects in salted fish associated with the raw material	Defect weight	Defect points	Main cause of problem
4. Miscellaneous defects			
4.1. Front side broken			Fish squeezed in net winch, between boards, boxes or elsewhere. Fish with front side broken may rupture during curing.
a) Front side is broken (close to root) but is otherwise intact.	IV	4	
b) Front side is broken through or off.	U	8	
4.2. Flaps loose from neck section			Incorrect handling at gutting. If the collar-bone is loose from the neck, the risk is that flaps will come loose, e.g. in heading machine. Other reasons exist.
a) One flap is torn away from neck about 1-2 cm.	II	1	
b) Both flaps torn away from neck about 1-3 cm or joined by the skin between flap and neck.	III	2	
4.3. Decomposition			Old and decayed raw material has been used for salting.
Yellow mucus covers the surface. Fish has a dull odour of putrefaction when cold; odour intensifies upon heating.	U	Non-gradable fish	
4.4. "Undesirable" condition			Mis-shapen fish, e.g. "cripples".
Unnaturally short, broad or mis-shapen fish.	II	1	
4.5. Fat fish			Fish has over-fed and is probably an abnormal variant.
Flaps unnaturally thin and large.	I	¼	
4.6. Seal bitten			
Parts missing, often from flaps.	U	8	
4.7. Algal colour			Fish has lain among algae.
Skin is coloured red or reddish-brown.	I	¼	

Summary of defect points and quality grades

Salted fish defect	Defect points	Quality grade
1. Defects associated with the raw material		
1.1. Blood defects		
1.1.1.a. Veins visible in flaps	1	2
1.1.1.b. Veins visible in flaps	2	3
1.1.1.c. Veins visible in flaps	4	4
1.1.1.d. Veins visible in flaps	8	U (5)
1.1.2.a. Mud colour	1	2
1.1.2.b. Mud colour	2	3
1.1.3.a. Bleeding cracks and fissures	2	3
1.1.3.b. Bleeding cracks and fissures	4	4
1.1.3.c. Bleeding cracks and fissures	8	U (5)
1.1.4.a. Contusions	1	2
1.1.4.b. Contusions	2	3
1.1.4.c. Contusions	4	4
1.1.4.d. Contusions	8	U (5)
1.1.5.a. Pooled blood	2	3
1.1.5.b. Pooled blood	4	4
1.1.6 Blood along back	¼	1
1.2. Fish flaccid		
1.2.1.a. Breaks	4	4
1.2.1.b. Breaks	8	U (5)
1.2.2.a. Fissures	1	2
1.2.2.b. Fissures	2	3
1.2.3.a. Autolysis	2	3
1.2.3.b. Autolysis	4	4
1.2.3.c. Autolysis	8	U (5)
1.3. Other defects originating from the raw material		
1.3.1. Worms	(Re-grade after removal)	
1.3.2.a. Flea-bitten fish	4	4
1.3.2.b. Flea-bitten fish	8	U (5)
1.3.3.a. Loose collar-bone	1	2
1.3.3.b. Loose collar-bone	2	3
1.3.3.c. Loose collar-bone	4	4

Salted fish defect		Defect point	Quality grade
1.3.4.	Emaciated fish	1	2
1.3.5.	Crab bites	1	2
1.3.6.a.	Hook injuries	1	2
1.3.6.b.	Hook injuries	2	3
1.3.6.c.	Hook injuries	4	4
1.4.	Defects caused by storage of raw material		
1.4.1.a.	Storage damage	1	2
1.4.1.b.	Storage damage	2	3
1.4.1.c.	Storage damage	4	4
1.4.2.a.	Frost damage	1	2
1.4.2.b.	Frost damage	2	3
1.4.2.c.	Frost damage	4	4
1.4.2.d.	Frost damage	8	U (5)
2.	Preparation damage		
2.1.	Heading damage		
2.1.1.	Punctured neck	1	2
2.1.2.	Crumbs	¼	1
2.2.	Splitting damage		
2.2.1.a.	Tail section closed	1	2
2.2.1.b.	Tail section closed	2	3
2.2.1.c.	Tail section closed	8	U (5)
2.2.2.a.	Cutouts in flaps	1	2
2.2.2.b.	Cutouts in flaps	2	3
2.2.3.	Split extends down to skin	1	2
2.2.4.a.	Splitting puncture	2	3
2.2.4.b.	Splitting puncture	4	4
2.2.5.	Deep cuts	½	1
2.2.6.	Spine split (shallow cut)	¼	1
2.2.7.	Spine too long (short)	½	1
2.2.8.	Air bladder fragments	¼	1

Salted fish defect		Defect points	Quality grade
2.3.	Cleaning defects		
2.3.1.a.	Liver spots	1	2
2.3.1.b.	Liver spots	2	3
2.3.1.c.	Liver spots	4	4
2.3.2.	Blood in neck section	½	1
2.3.3.	Yellow mucus	½	1
2.3.4.a.	Blood spots	½	1
2.3.4.b.	Blood spots	1	2
3.	Salting and storage damage		
3.1.a.	Mis-salting	2	3
3.1.b.	Mis-salting	4	4
3.2.	Dusky fish	½	1
3.3.	Crusts	½	1
3.4.	Tail closed	½	1
3.5.	Copper yellow	Non-gradable fish	
3.6.	Moulds	Non-gradable fish	
3.7.	Rot	Non-gradable fish	
4.	Miscellaneous defects		
4.1.a.	Front side broken	4	4
4.1.b.	Front side broken	8	U (5)
4.2.a.	Flaps loose from neck section	1	2
4.2.b.	Flaps loose from neck section	2	3
4.3.	Decomposition	Non-gradable fish	
4.4.	"Undesirable" condition	1	2
4.5.	Fat fish	¼	1
4.6.	Seal bitten	8	U (5)
4.7.	Algal colour	¼	1

5.2. Grading scale of the Fish Products Inspectorate

Cod

1st grade. First grade fish must be unblemished and free of defects. There must be no autolysis and the fish must be free of breaks and fissures.

The fish must be suitably firm and smooth in appearance. It must be ascertained that no extraneous material has adversely affected the quality of the fish.

The fish must have the pleasing natural white colour of salted fish.There must be no miscolouring from poor bleeding, mis-salting, use of impure salt, poor washing etc.

No veins must be visible in the flaps, and the flaps must harmonize in colour with other surface areas of the fish.

Splitting must have been so performed that the quality and appearance of the fish remain unspoiled.

There must be no visible hook punctures.

The fish must contain no traces of viscera including guts, air bladder fragments, liver etc.

There must be no blood from the neck or spine in the fish.

Fish showing yellow spots underneath liver fragments or neck blood must not be classified as 1st grade.

No worms or cankers must be present in the fish.

2nd grade. Second grade fish must be comparable to first grade in terms of consumption quality. Various minor defects which do not affect its consumption quality, are permitted.

Dull veins may be visible in the flaps.

Minor splitting damage, insignificant punctures and similar minor defects are allowed.

The overall effect of these defects must not diminish the consumption quality of the fish.

3rd grade. Inferior fish with more defects than allowed in second grade, but which are not significantly poorer in terms of consumption quality, are classified as 3rd grade.

Flaps may be loose at the front from the neck. Minor fissures are permitted, but not in the main fleshy areas.

Normal veins may be seen in the flaps, as well as minor blood spots. Overall colouring must be good, although the fish may appear duller than allowed in 1st grade.

Inconspicuous splitting damage, visible hook punctures which do not appear as bloody blotches or tears, are permitted.

4th grade. Fourth grade is assigned to fish with major defects, including conspicuous worms and blood spots. Consumption quality is diminished, but the fish remains suitable for human consumption.

The fish may have various fissures and broken areas, but the neck section flesh must be intact and the fish not broken.

Flaps may be loose from the neck on both sides.

Darker colour is permitted than in grades 1-3. However, the fish must not be yellow or darkened due to contamination or other circumstances.

Normal veins, more conspicuous than in 3rd grade, may be visible, as well as major blood spots which, however, must not be joined.

Prominent hook punctures and splitting defects are permitted. Worms may be found in this grade.

We repeat that red or mouldy fish must not be included in this or other grades. If such defects are found, grading should be suspended.

Other species of fish.

As shown above, the grading of cod is the basis for export grading of all species of uncured salted fish. Grading of other species must consequently follow the same rules, taking into account the following:

1. Coal-fish

a) Allowance must be made for the darker colour of coal-fish compared to cod.
b) Coal-fish may become rancid if it is old or improperly stored. A careful watch must be kept for signs of rancidity. If the fish is significantly rancid, it must be discarded.
c) During grading, special account must be taken of any fatty deposits on the coal-fish. Minor fatty deposits relegate the fish to 2nd grade, larger deposits or spots to 3rd grade. If there is general evidence of fat over the fish surface, the coal-fish must be assigned to fourth grade.

2. Haddock

a) Some allowance must be made for the fact that haddock flaps generally are darker than cod flaps, and tend more often to be loose from the neck.
b) No veins must be visible in 1st grade haddock.

5.3. Taste and consumption quality of salted fish.

As indicated in section 1, the perception of taste quality is a highly subjective matter. There is no method of precisely defining the characteristics a consumer is looking for; besides, consumers differ in terms of their tastes and attitudes. We must rely on general quality grading to classify salted fish according to consumption quality into main categories. Those defects which relegate a fish from 1st to a lower grade all diminish the consumption quality of the fish, i.e. the consumer's perception of quality, and every aspect of its appearance has some importance. In addition the flavour deteriorates along with certain defects. Tasting experiments have shown that breaks and fissures also have a negative effect on taste. Such fish was found to be "tougher", "coarser" and "drier" than comparable, unblemished, fish. Breaks and fissures must be considered much more serious defects if flavour is also adversely affected. Fish bled after death and containing veins and other bleeding defects were found in these experiments to taste inferior to unblemished fish. Such fish was claimed to "taste worse" without being "coarser" or "tougher" than 1st grade fish. All indications are that fish with raw material defects fare worse in tasting experiments than other fish; however, no definitive findings have been presented in this matter.

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